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In Situ Bioremediation Remedial Action Work Plan for Test Area North Final Groundwater Remediation, Operable Unit 1-07B

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Revision 1

In Situ Bioremediation Remedial Action Work Plan for Test Area North Final Groundwater Remediation, Operable Unit 1-07B

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ABSTRACT

This Remedial Action Work Plan for Test Area North, Operable Unit 1-07B, final groundwater remediation identifies the approach and requirements for the implementation of in situ bioremediation as the hot spot remedy. A separate remedial design will be submitted providing drawings, specifications, and plans for construction of the hot spot remedy. Additionally, an Operations and Maintenance Plan and Groundwater Monitoring Plan will be prepared as a separate submittal to implement the requirements detailed in the Remedial Design/Remedial Action Work Plan.

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ACRONYMS

ARAR	applicable or relevant and appropriate requirement
ARD	anaerobic reductive dechlorination
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	contaminant of concern
D&D&D	deactivation, decontamination, and decommissioning
DOE	Department of Energy
DOE-ID	Department of Energy Idaho Operations Office
DQO	data quality objective
EPA	Environmental Protection Agency
FFA/CO	Federal Facility Agreement and Consent Order
GWMP	Groundwater Monitoring Plan
HASP	Health and Safety Plan
IDAPA	Idaho Administrative Procedures Act
IDEQ	Idaho Department of Environmental Quality
INEEL	Idaho National Engineering and Environmental Laboratory
IRC	INEEL Research Center
ISB	in situ bioremediation
M&O	management and operating (contractor)
MCL	maximum contaminant level
MNA	monitored natural attenuation
NCP	National Contingency Plan
NLCID	no longer contained-in determination
NPTF	New Pump and Treat Facility
NPV	net present value
O&M	operation and maintenance

OU	operable unit
PCB	polychlorinated biphenyl
PDO	predesign operations
PDP	predesign phase
PM/CM	performance/compliance monitoring
RAO	remedial action objective
RAWP	Remedial Action Work Plan
RCRA	Resource Conservation and Recovery Act
RD/RA	remedial design/remedial action
ROD	Record of Decision
SOW	Scope of Work
TAN	Test Area North
TFR	technical and functional requirement
TSF	Technical Support Facility
VOC	volatile organic compound
WAG	waste area group
WMP	Waste Management Plan

In Situ Bioremediation Remedial Action Work Plan for Test Area North Final Groundwater Remediation, Operable Unit 1-07B

1. INTRODUCTION

This Remedial Action Work Plan (RAWP) has been prepared in accordance with the Idaho National Engineering and Environmental Laboratory (INEEL) Federal Facility Agreement and Consent Order (FFA/CO) (DOE-ID 1991) by the Department of Energy Idaho Operations Office (DOE-ID). The plan addresses the implementation of in situ bioremediation (ISB) as the hot spot remedy of the Test Area North (TAN) Technical Support Facility (TSF) injection well (TSF-05) and surrounding groundwater contamination (TSF-23). The groundwater plume that emanates from TSF-05 has been designated as Operable Unit (OU) 1-07B. This Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 USC § 9601 et seq.) remedial action will proceed in accordance with the signed OU 1-07B Record of Decision (ROD) Amendment (DOE-ID 2001a). The *Remedial Design and Remedial Action Scope of Work Test Area North Final Groundwater Remediation Operable Unit 1-07B* (DOE-ID 2001b) identifies and describes the scope, schedule, and budget the Agencies have agreed are necessary for the implementation of this remedial action (in accordance with the 2001 ROD amendment).

The ROD amendment (DOE-ID 2001a) modifies the original remedy for OU 1-07B at TAN. The modification was chosen in accordance with CERCLA, as amended by the Superfund Amendments and Reauthorization Act of 1986 and to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 CFR 300). The documents that form the basis for the decisions made in the ROD amendment are contained in the administrative record for OU 1-07B. This decision satisfies the requirements of the FFA/CO entered into among the Department of Energy (DOE), the Environmental Protection Agency (EPA), and the Idaho Department of Environmental Quality (IDEQ), hereafter known as the Agencies.

1.1 Remedial Action Summary

The remedial design/remedial action (RD/RA) scope of work (SOW) (DOE-ID 2001b) defines the scope, schedule, and budget for implementation of the OU 1-07B final remedial action, as required by CERCLA (42 USC § 9601 et seq.), the FFA/CO (DOE-ID 1991), and in accordance with the ROD amendment (DOE-ID 2001a). The final remedy for OU 1-07B clean-up combines ISB for hot spot restoration and monitored natural attenuation (MNA) for distal zone restoration with pump-and-treat (selected in the 1995 ROD [DOE-ID 1995]) for the medial zone, providing a comprehensive approach to the restoration of the contaminant plume. The remedy also includes groundwater monitoring and institutional controls. The remedy for OU 1-07B will prevent current and future exposure of workers, the public, and the environment to contaminated groundwater at TSF-05, the injection well site. Table 1-1 lists the contaminants of concern (COCs) in the vicinity of the TSF-05.

Table 1-1. Contaminants of concern in the vicinity of the TSF-05 injection well.

Contaminant	Maximum Concentrations[a]	Federal Drinking Water Standard
VOLATILE ORGANIC COMPOUNDS		
Trichloroethene (TCE)	12,000 – 32,000 ppb	5 ppb[b]
Tetrachloroethene (PCE)	110 ppb	5 ppb[b]
cis-1,2-Dichloroethene (DCE)	3,200 – 7,500 ppb	70 ppb[b]
trans-1,2-DCE	1,300 – 3,900 ppb	100 ppb[b]
RADIONUCLIDES		
Tritium	14,900 – 15,300 pCi/L[c]	20,000 pCi/L
Strontium-90	530 – 1,880 pCi/L	8 pCi/L
Cesium-137	1,600 – 2,150 pCi/L	119 pCi/L[d]
Uranium-234	5.2 – 7.7 pCi/L[c]	27 pCi/L[e]

ppb = parts per billion pCi/L = picocuries per liter

a. The concentration range is taken from measured groundwater concentrations at the TSF-05 injection well (INEEL 1999a).

b. ppb is a weight-to-weight ratio that is equivalent to micrograms per liter (μg/L) in water.

c. Maximum concentrations of tritium and U-234 are below federal drinking water standards and baseline risk calculations indicate cancer risk of 3×10^{-6}. While this risk is smaller than 1×10^{-4}, both tritium and U-234 are included as COCs as a comprehensive plume management strategy.

d. The MCL for Cs-137 is derived from a limit of 4 millirem per year (mrem/yr) cumulative dose-equivalent to the public, assuming a lifetime intake of 2 liters per day (L/day) of water.

e. The federal drinking water standard for U-234 is for the U-234, -235, and -238 series.

This remedial action will permanently reduce the toxicity, mobility, and volume of the contamination at the site. The components of the remedy for restoration of the OU 1-07B hot spot, medial zone, and distal zone of the contaminant plume (illustrated conceptually in Figure 1-1) include:

- **Hot Spot**—In situ bioremediation promotes bacterial growth by supplying essential nutrients to bacteria that are able to break down contaminants and naturally occur in the aquifer. An amendment (such as sodium lactate or molasses) is injected into the secondary source area through the TSF-05 injection well or into other wells in the immediate vicinity. Amendment injections increase the number of bacteria, thereby increasing the rate at which the volatile organic compounds (VOCs) break down into harmless compounds. The amendment supply is distributed as needed, and the treatment system operates year-round.

- **Medial Zone**—Pump-and-treat involves extraction of contaminated groundwater, treatment through air strippers, and reinjection of treated groundwater. Air stripping is a process that brings clean air into close contact with contaminated liquid allowing the contaminants to pass from the liquid into the air, where they quickly evaporate. In accordance with the original remedy selected in the 1995 ROD (DOE-ID 1995), construction of the New Pump-and-Treat Facility (NPTF) in the medial zone was completed in January 2001. The facility started routine operations on October 1, 2001.

- **Distal Zone**—Natural attenuation is the physical, chemical, and biological processes that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in groundwater. MNA includes groundwater monitoring with annual performance reviews for the first 5 years (followed by additional periodic reviews) to compare actual natural degradation rates to predicted degradation rates.

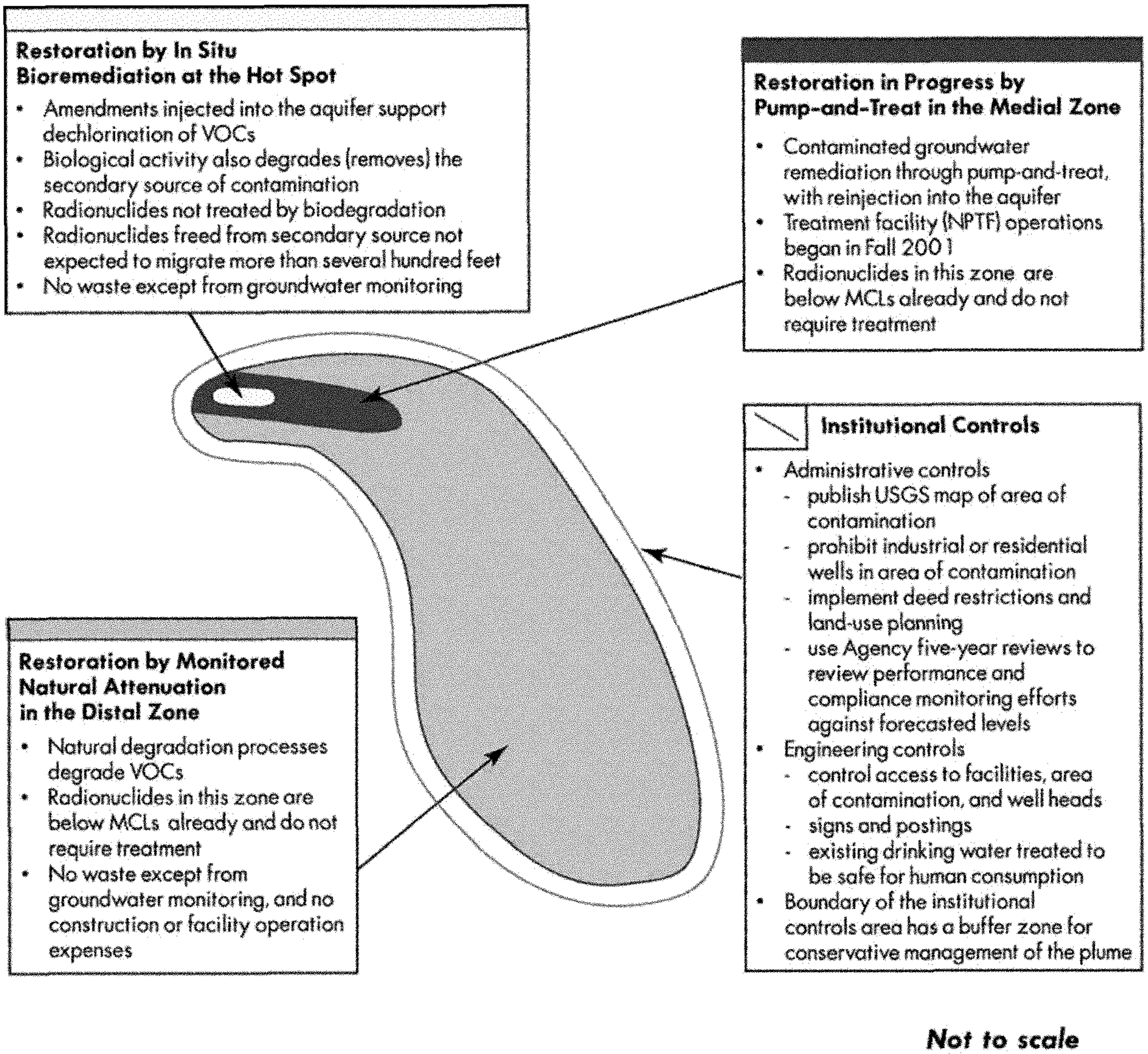


Figure 1-1. Conceptual illustration of the components of the amended remedy.

- **Institutional Controls**—Engineering and administrative controls will be put in place to protect current and future users from health risks associated with groundwater contamination. During the early part of the restoration timeframe, the contaminant plume continues to increase slowly in size until the natural attenuation process overtakes it. Modeling suggests that growth of the distal zone of up to 30% might occur, reaching its maximum size in about 2027 (as defined by the 5 ppb tetrachlorethene (TCE) isopleth). However, since institutional controls will be in place, there will be no change in risk to human health or to ecological receptors. Under this alternative, continued groundwater monitoring and computer modeling will be used to track the plume boundary; the institutional controls area will be modified, as required, to maintain a conservative buffer zone around the contaminant plume area.

- **Monitoring**—Groundwater monitoring will be conducted throughout the plume, with samples analyzed to determine the progress of the remedy. Water level measurements will be completed to verify the ability of the NPTF to contain and treat the contaminants in the medial zone.

- **Contingencies**—Contingencies identified under the remedy include:
  - For the medial zone, monitoring wells located upgradient of the NPTF will be monitored on a routine basis to ensure that concentrations of radionuclides in the groundwater remain low. If monitoring indicates that the concentration of radionuclides in the NPTF effluent would exceed maximum contaminant levels (MCLs), the Air Stripper Treatment Unit (ASTU), located between the hot spot and the NPTF but not currently operating, will be used to prevent those radionuclides from traveling downgradient to the NPTF.
  - For the distal zone, if the Agencies determine that MNA will not restore the distal zone of the plume within the restoration timeframe, pump-and-treat units will be designed, constructed, and operated in the distal zone to remediate the plume. The contingency remedy also will be invoked if the required monitoring necessary for MNA is not performed.

Under the remedy, the concentrations of the radionuclide COCs in the hot spot and medial zone will meet the remedial action objectives (RAOs) of the ROD within the remedial timeframe through natural attenuation processes. Concentrations of the radionuclide COCs in the distal zone already meet the RAOs. The groundwater monitoring program will include monitoring the attenuation of radionuclide COCs in the hot spot and the medial zone. If monitoring indicates that the concentration of radionuclides in the NPTF effluent would exceed MCLs, then the medial zone contingency would be implemented. The frequency of monitoring at selected medial zone and distal zone locations depends on the potential risk of exceeding MCLs in the NPTF effluent. The Agencies will use the monitoring results to determine appropriate responses.

1.2 Scope of the In Situ Bioremediation Remedial Action

This RAWP outlines a comprehensive process that follows the governing CERCLA and FFA/CO requirements for implementation of ISB at TAN. This step-by-step process integrates project team input and agency input at critical milestones in accordance with the RD/RA SOW (DOE-ID 2001b). This RAWP has been developed in concert with several supporting documents to establish the basis for long-term ISB operations. It identifies and establishes the ISB system technical and functional requirements (TFRs), design requirements, applicable or relevant and appropriate requirements (ARARs), and the requirements for operation, monitoring, and reporting. The supporting documentation provides technical methods, procedures, and protocols for implementing the requirements defined in this RAWP. This document has been reviewed in accordance with governing FFA/CO requirements for primary documents. Appendix A contains Agency comments and the comment resolutions from the agency review of the ISB RAWP (Draft) version of the document. Appendix B contains comments and comment resolutions from the Agency review of the ISB RAWP (Draft Final) version. The following sections establish the requirements for several key areas, which are summarized in the following sections. These requirements are established to guide the remedial action implementation in achieving the RAOs, including the compliance and performance requirements set forth in Section 2.

1.2.1 Technical and Functional Requirements

This RAWP provides the problem statement and technical basis necessary to develop the ISB TFRs. These requirements identify the operation and performance requirements necessary to prepare the ISB design. They are established to bracket the key operating and monitoring parameters that are necessary for the ISB system to achieve the RAOs. This RAWP summarizes the primary elements of the ISB TFRs that the Agencies have agreed are the ISB design basis.

1.2.2 Remedial Design

This RAWP describes the design preparation and approval process, including a discussion of the proposed design. This will include a brief description of the process facility and its capabilities, along with descriptions and capabilities of support structures, appurtenances, and ancillary equipment.

1.2.3 Agency Remedial Design/Remedial Action Review and Approval

The CERCLA and FFA/CO process, the ROD (DOE-ID 1995), and the RD/RA SOW (DOE-ID 2001b) require Agency input, review, and concurrence at the completion of certain actions and prior to starting other actions. This RAWP integrates project team and agency review, inspection, and input into the required areas during the process of implementing this remedial action and defines the objectives, procedures, and process by which the Agencies and the project will review and concur with the remedial action. Additionally, the process by which the Agencies can concur that the remedial action is operational and functional is presented. This process will be comprised of a shakedown and initial operational period with clear and measurable performance criteria and objectives, an operational and monitoring strategy showing attainment of the stated objectives, and the preparation of the ISB remedial action report. This process will include requirements for agency prefinal and final inspections, if required.

1.2.4 Interim Operations

Interim operations are the period between the approval of this RAWP and the start of initial operations. Initial operations will start with the completion of the new ISB injection facility. Interim operations will be a continuation of the pre-design operational activities and will cover activities that support selection of an electron donor, development of electron donor injection strategies, ISB model refinement, and continued ISB groundwater monitoring.

1.2.5 Remedial Action Construction

This RAWP identifies and defines activities, processes, hold-points, inspections, and other requirements necessary to ensure that the remedial construction meets the quality and regulatory requirements specified in the remedial design.

1.2.6 Operation

This RAWP will define the operational strategy that meets the ROD, RAOs, and performance and compliance requirements. This will include defining the requirements for procedures, protocols, and processes that will govern routine operations.

1.2.7 Groundwater Monitoring

The requirements for a groundwater monitoring strategy will be developed that provide the data necessary to evaluate the effectiveness of ISB at achieving stated remedial action performance and compliance objectives. This RAWP shall establish the data quality objectives (DQOs) and the quantity, quality, and type of analysis necessary to objectively measure performance.

1.2.8 Agency Remedy Performance Review

This RAWP lays out the basis by which the Agencies will perform remedy performance reviews; establish the basis by which performance will be measured; and delineate the process, format, and schedule of reports, inspections, and reviews.

2. REMEDIAL ACTION OBJECTIVES

Remedial action objectives were defined in the 1995 ROD to specify expected remedy performance during the three phases of the 1995 ROD remedy implementation strategy. One RAO was defined for each of three phases: Phase A, Phase B, and Phase C. A separate RAO was defined for the institutional controls to ensure the controls remained in place during the life of the remedial action. Changes documented in the *Explanation of Significant Differences from the Record of Decision for the Technical Support Facility Injection Well (TSF-05) and Surrounding Groundwater Contamination (TSF-23) and Miscellaneous No Action Sites, Final Remedial Action* (INEEL 1997a) and results of the treatability studies led to a revision of the RAOs for Phase C. These modified RAOs for Phase C have been adopted as the final RAOs, as discussed below.

2.1 Remedial Action Objectives Defined in the 2001 Record of Decision

Changes and results documented in the explanation of significant differences (INEEL 1997a) and the *Field Demonstration Report, Test Area North Final Groundwater Remediation, Operable Unit 1-07B* (DOE-ID 2000a) prompted a refinement of the RAOs for Phase C. The Agencies agreed to the following final RAOs for the entire contaminant plume:

- Restore the contaminated aquifer groundwater by 2095 (100 years from the signature of the 1995 ROD) by reducing all COCs to below MCLs and a 1×10^{-4} total cumulative carcinogenic risk-based level for future residential groundwater use and, for noncarcinogens, until the cumulative hazard index is less than 1.

- For aboveground treatment processes in which treated effluent will be reinjected into the aquifer, reduce the concentrations of VOCs to below MCLs and a 1×10^{-5} total risk-based level.

- Implement institutional controls to protect current and future users from health risks associated with 1) ingestion or inhalation of, or dermal contact with, contaminants in concentrations greater than the MCLs, 2) contaminants with greater than a 1×10^{-4} cumulative carcinogenic risk-based concentration, or 3) a cumulative hazard index of greater than 1, whichever is more restrictive. The institutional controls shall be maintained until concentrations of all COCs are below MCLs and until the cumulative carcinogenic risk-based level is less than 1×10^{-4} and, for noncarcinogens, until the cumulative hazard index is less than 1. Institutional controls shall include access restrictions and warning signs.

Restoration of the hot spot under the remedy will not directly affect radionuclide concentrations in groundwater. The geochemical behavior of the radionuclides in the subsurface acts to bind them to soil and rock in the area where they are located. This will continue to prevent them from migrating beyond the vicinity of the hot spot and from being available to future drinking water users. This behavior supports the presumption that, throughout the restoration period, radionuclide concentrations in water extracted from the aquifer downgradient from the hot spot will remain below MCLs and 1×10^{-4} cumulative carcinogenic risk-based levels and, for noncarcinogens, the cumulative risk will remain less than 1. Estimates of radionuclide attenuation by sorption and radioactive decay indicate that Cs-137 and Sr-90 will meet RAOs throughout the contaminant plume by 2095. Sorption of radionuclides from the dissolved phase to subsurface materials prevents these radionuclides from being present in the drinking water of future users. The remaining radionuclides (U-234 and tritium) are currently below MCLs and 1×10^{-4} cumulative carcinogenic risk-based levels.

2.2 Compliance and Performance Objectives for In Situ Bioremediation

The general compliance and performance monitoring objectives for ISB consist of demonstrating meaningful progress toward restoration of the hot spot-contaminated aquifer groundwater by 2095 (100 years from the signature of the 1995 ROD) by reducing all COCs to below MCLs and a 1×10^{-4} total cumulative carcinogenic risk-based level for future residential groundwater use and, for non-carcinogens, until the cumulative hazard index is less than 1. These monitoring objectives will be met through the collection of monitoring data that demonstrate (1) complete dechlorination of VOCs to prevent (to the maximum extent practicable) migration of VOCs above MCLs beyond the hot spot, (2) degradation of the source area and (3) restoration of the plume by 2095. These objectives are divided into three specific compliance objectives and two performance objectives, as follows:

Compliance Objectives:

- Reduce downgradient flux from the hot spot such that VOC concentrations are less than MCLs
- Reduce crossgradient flux from the hot spot such that VOC concentrations are less than MCLs
- Maintain the reduction of downgradient and crossgradient flux from the hot spot of VOC concentrations below MCLs.

Performance Objectives:

- Achieve electron donor distribution throughout the hot spot and associated biogeochemical reactions
- Achievement of source degradation.

2.3 In Situ Bioremediation Implementation Strategy

For the OU 1-07B ISB remedial component, a phased implementation strategy is planned. The planned implementation strategy provides a sequenced approach designed to provide the time necessary to optimize electron donor addition prior to the start of long-term operations and to monitor secondary source degradation. The ISB implementation phases are:

1. Interim Operations – Interim operations will be a continuation of the predesign operational activities and will cover activities that support a better understanding of alternate electron donors, development of injection strategies that support initial operations, ISB model refinement, and continued ISB lactate addition.

2. Initial Operations – This phase will focus on reducing the flux of VOCs from the hot spot in the downgradient direction. During this phase, data will also be gathered and analyzed relating to achievement of long-term performance objectives.

3. Optimization Operations – This phase will focus on reducing the flux of VOCs from the hot spot in the crossgradient direction, while maintaining VOC flux reduction in the downgradient direction. During this phase, data will continue to be gathered and analyzed relating to achievement of long-term performance objectives.

4. Long-term Operations – This phase will focus on achievement of hot spot source degradation, while maintaining the reduction of VOC flux from the hot spot in the crossgradient and downgradient directions.

Each phase has specific completion criterion which, when achieved, lead to the next phase or completion of the remedy component. The completion criteria for a given phase require the monitoring and evaluation of certain ISB performance parameters. Table 2-1, the ISB RAO performance/compliance matrix, contains the description of the objectives for each phase, the completion criteria, and the performance and compliance monitoring requirements for evaluating. A summary schedule of the ISB implementation strategy is presented in Figure 2-1.

The performance and compliance monitoring requirements and objectives presented in this section are strictly related to ISB. The ISB Groundwater Monitoring Plan provides the implementation strategy and requirements for the ISB monitoring program. Section 1 of this plan defines the three remedial components of this remedial action. Table 2-2 provides a crosswalk between the three monitoring zones, remedy performance, and compliance monitoring requirements. Table 2-2 also further devines which project documents retain the requirements and instruction for that particular sampling program.

The success of the overall remedial action is dependent on each remedial component performing as planned. Each remedial component is dependent on the others in order to achieve remediation goals. The monitoring program for each remedial component provides the data to evaluate the performance of each component, as well as the overall remedial action. It is important to understand the interaction between monitoring programs. As remedial componenents are completed, a comprehensive monitoring program will continue to provide data necessary to evaluate attainment of all remedial action objectives. Figure 2-2 provides an illustration of the interaction of various remedy components' monitoring programs over the life of the remedy.

Table 2-1. In situ bioremedial remedial action objective performance and compliance monitoring objectives.

Remedy Phase Objective	Monitoring Phase/Decision Types[1,2]		Criteria for completion of the Phase	Notes
	Performance	Compliance		
Interim Operations Continue system operations to reduce contaminant flux from the hot spot	Routinely monitor performance of the ISB system with respect to indicator parameters including VOCs, tritium, ethene/ethane/methane, redox parameters, electron donor, bioactivity, and nutrients; determine whether or not operational changes are required.	N/A	Completion is defined as start-up of the final remedy treatment system	
Initial Operations This phase will focus on reducing the flux of VOCs from the hot spot in the downgradient direction. During this phase, data will also be gathered and analyzed relating to achievement of long-term performance objectives.	Routinely monitor performance of the ISB system with respect to indicator parameters including VOCs, tritium, ethene/ethane/methane, redox parameters, electron donor, bioactivity, and nutrients; determine whether or not operational changes are required.	Monitor concentrations of VOCs at TAN-28 and –30A for a period of one year to verify concentrations remain below MCLs.	Determine that for a period of 1 year, downgradient flux from the hot spot has been reduced such that VOC concentrations remain less than MCLs, as measured at TAN-28 and –30A.	Initial operations starts with completion of construction.
Optimization Operations This phase will focus on reducing the flux of VOCs from the hot spot in the crossgradient direction, while maintaining VOC flux reduction in the downgradient direction. During this phase, data will continue to be gathered and analyzed relating to achievement of long-term performance objectives.	Routinely monitor performance of the ISB system with respect to indicator parameters including VOCs, tritium, ethene/ethane/methane, redox parameters, electron donor, bioactivity, and nutrients; determine whether or not operational changes are required.	Monitor concentrations of VOCs at Wells PMW-1 and PMW-2 for a period of one year to verify that concentrations remain below MCLs.	Determine that for a period of 1 year, crossgradient flux from the hot spot has been reduced such that VOC concentrations remain less than MCLs as measured at PMW-1 and PMW-2.	Optimization starts at the end of initial operations. - The completion of optimization operations will lead to a Remedial Action Report and a functional and operational determination. - PM/CM reports periodic with frequency no less than every 5 years.
Long-Term Operations This phase will focus on achievement of hot spot source degradation, while maintaining the reduction of VOC flux from the hot spot in the crossgradient and downgradient directions.	Routinely monitor performance of the ISB system with respect to indicator parameters including VOCs, tritium, ethene/ethane/methane, redox parameters, electron donor, bioactivity, and nutrients; determine whether or not operational changes are required.	N/A	The completion criteria for long-term operations will be specified in the ISB Remedial Action Report.	- PM/CM reports periodic with frequency no less than every 5 years. - Long-term operations start at the completion of optimization.

ISB = in situ bioremediation VOC = volatile organic compounds MCL = maximum contaminant level PM/CM = performance/compliance monitoring

1. Decision Types are inputs to the data quality objectives Process described in the Groundwater Monitoring Plan .

2. VOCs: PCE, TCE, cis- and trans-DCE, vinyl chloride

Redox parameters: pH, ORP, dissolved oxygen, ferrous iron and sulfate
Electron donor: COD, specific conductivity, lactate, acetate, propionate, butyrate
Bioactivity: alkalinity
Nutrients: ammonia, nitrogen, orthophosphate.

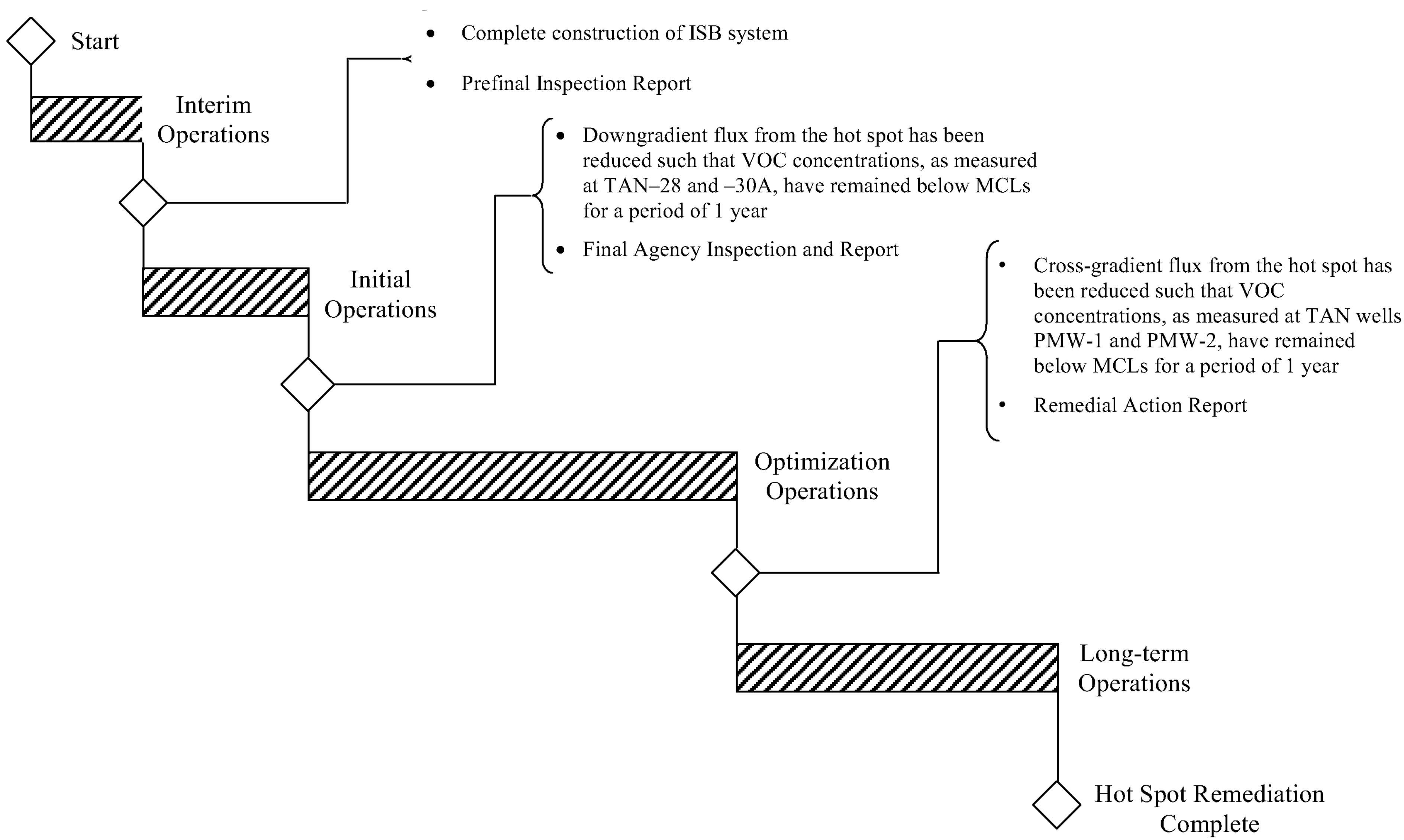


Figure 2-1. Summary schedule of the in situ bioremediation implementation strategy.

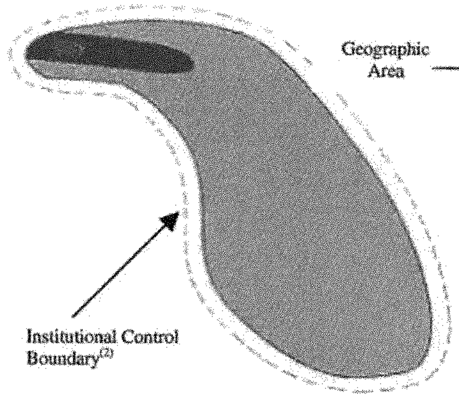
Table 2-2. Operable Unit 1-07B groundwater remediation remedy monitoring crosswalk table.

Monitoring Zone	Monitoring Type	Sample Parameter	Decision/Evaluation Objective	Goal	Sample Program	Basis Document
Hot Spot	ISB Performance	ISB Performance Parameters • VOCs • Tritium • Ethene, ethane, methane, redox, electron donor, bioactivity, and nutrient	Trending • Donor Distribution • Source Degradation • Flux • New Donor	Optimize operation to meet compliance objectives/requirements	ISB	ISB Work Plan
				Achieve reduction of crossgradient flux to below MCLs	ISB	ISB Work Plan
	ISB Compliance	VOCs (TAN-28 & 30A)	VOCs below MCLs for 1 year	Achieve reduction of downgradient flux to below MCLs	ISB	ISB Remedial Action Report
		VOCs (PMW-1 & 2)	VOCs below MCLs for 1 year			
			Hot Spot Completion	Determine ISB RAOs have been met in the Hot Spot.	NPTF	NPTF Work Plan
	ISB Completion Compliance	All VOCs (Wells TBD)	Upgradient Source	NPTF contingency evaluation monitoring.	MNA	MNA Work Plan
			Upgradient Radionuclide Monitoring (Hot Spot)	Monitor/Evaluation Hot Spot radionuclide degradation and migration.		
	NPTF Performance	VOCs plus radionuclides (strontium, cesium) (Wells TBD)				
	MNA Performance	Radionuclides (strontium and cesium) [TAN-25, -37a and b, -28, -30A, -29 and TSF-05a and b]				
Medial Zone	NPTF Performance	Draw down	Facility Operations	Plume Capture	NPTF	NPTF Work Plan
	NPTF Compliance	Facility influent/effluent VOCs and strontium	Facility Operations	Stay within influent and effluent specifications	NPTF	NPTF Work Plan
		Air Emissions	Facility Operations	Stay within effluent specifications		NPTF Work Plan
		Operations Uptime	Facility Operations	Maintain 90% uptime		
		Extraction Flow Rate	Facility Operations	Operate within specified flow rate	NPTF	
	NPTF Completion Compliance	All COCs (Wells TBD)	Medial Zone Completion	Determine that NPTF RAOs have been or can be met in the Medial Zone.		
Distal Zone	MNA Performance	TCE/Tritium	Breakthrough Curves	Trends are toward achievement of RAOs	MNA	MNA Work Plan
			Plume Expansion			
			Degradation Rate			MNA Work Plan
	MNA Compliance	Annual for 5 years		Annual sampling a requirement for at least the first 5 years	MNA	MNA Remedial Action Report
	MNA Completion Compliance	All COCs	MNA Performance Parameters	Determine that RAOs have been met through-out the Plume	MNA	
			Remedial Action Completion			

ISB = in situ bioremediation VOC = volatile organic compounds MCL = maximum contaminant level PM/CM = performance/compliance monitoring
NPTF = New Pump and Tread Facility RAO = remedial action objectives MNA = monitored natural attenuation TBD = to be determined COC = contaminants of concern

2001-2015[1]

Operations during this period consist of ISB at the Hot Spot, NPTF at the Medial Zone, and MNA in the Distal Zone. It is assumed that ISB has successfully achieved the completion criteria for performance operations, which consist of stopping VOC flux from the Hot Spot.



Geographic Area →

Monitoring Program

Hot Spot	Medial Zone	Distal Zone	Remedy Component
ISB Performance ISB Compliance			ISB
NPTF Performance (NPTF Contingency)	NPTF Performance NPTF Compliance		NPTF
MNA[3] Performance (Radionuclide)	N/A	MNA [3] Performance	MNA

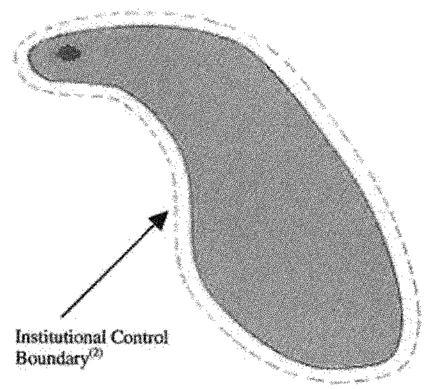
2016-2020[1]

Operations during this period consist of ISB at the Hot Spot and MNA for the Distal Zone[4]. It is assumed that the NPTF has successfully achieved the Medial Zone completion criteria and is in standby mode.

Geographic Area →

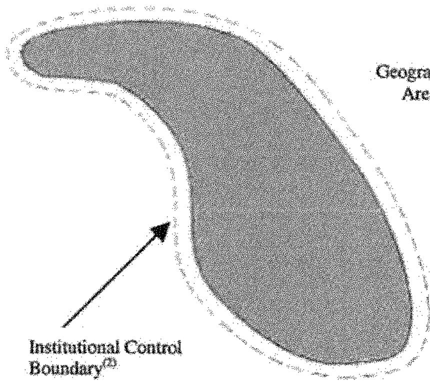
Monitoring Program

Hot Spot	Medial Zone	Distal Zone	Remedy Component
ISB Performance ISB Compliance			ISB
N/A	N/A		NPTF
MNA Performance (Radionuclide)	MNA Performance[5]	MNA Performance	MNA



2021-2095[1][6]

Operations during this period consist of MNA in the Distal Zone[4]. It is assumed for this period that ISB has successfully achieved the completion criteria for long-term operations and not only has the flux been cutoff, but the source has been degraded.



Geographic Area →

Monitoring Program

Hot Spot[7]	Medial Zone	Distal Zone	Remedy Component
			ISB
			NPTF
MNA Performance[5] (Radionuclide)	MNA Performance[5]	MNA Performance	MNA

(1) The dates and the shape of the plume shown are for illustrative purposes only.
(2) The institutional control boundary extends 40% beyond the current dimensions of the plume: 30% to account for expansion and an extra buffer of 10%.
(3) MNA compliance requirements during this period consist of annual monitoring for at least the first 5 years.
(4) The Distal Zone is defined as the areal extent of the plume that is less than 1,000 µg/L TCE and greater than 5 µg/L TCE.
(5) The MNA monitoring program will be expanded to include additional wells to be monitored for MNA performance parameters.
(6) Assumes the Hot Spot has been removed.
(7) ISB or some yet to be determined technology will operate at the Hot Spot until Hot Spot RAOs are achieved.

Figure 2-2. Generalized monitoring program operations throughout the remedy timeframe.

3. STATUTORY DETERMINATIONS AND APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENT COMPLIANCE

Under CERCLA, Section 121, and the NCP (40 CFR 300), the Agencies must select remedies that are protective of human health and the environment, comply with ARARs, are cost-effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that employ, as a principal element, treatment that permanently and significantly reduces the toxicity, mobility, or volume of hazardous waste, and has a bias against offSite disposal of untreated waste. Section 9 of the ROD Amendment (DOE-ID 2001a) discusses how the ISB meets these statutory requirements.

Implementation of the remedy will comply with the substantive portions of all specified ARARs. Table 3-1 lists the ARARs that are applicable to the ISB remedial component.

3.1 Compliance with Applicable or Relevant and Appropriate Requirements

Remedial actions at CERCLA sites must establish and comply with the substantive portions of the legal applicable or relevant and appropriate federal and state requirements, standards, criteria, and limitations (collectively referred to as ARARs), as required by Section 121(d) of CERCLA (42 USC § 9601 et seq.) and NCP Section 300.430(f)(1)(ii)(B). The following are excerpts from the ROD Amendment (DOE-ID 2001a).

3.1.1 Clarification of Applicable or Relevant and Appropriate Requirements

In accordance with IDAPA 37.03.03.050.01, which deals with the construction and use of injection wells, the Agencies have agreed that, to support ISB, amendments containing constituents above MCLs may be injected so long as injected fluid will not endanger a drinking water or groundwater source for any present or future beneficial use (DOE-ID 2001a).

3.1.2 Threshold Criteria

The threshold criteria requirements for ISB include (1) overall protection of human health and the environment, and (2) compliance with ARARs.

3.1.2.1 Overall Protection of Human Health and the Environment. In site bioremediation will be protective of human health and environment by eliminating, reducing, and controlling the risks posed by the Site through treatment of groundwater contaminants. In site bioremediation will treat the groundwater contaminants by injecting an amendment that will enhance biological growth resulting in dechlorination of contaminants within the hot spot without bringing the contaminated groundwater to the surface. In site bioremediation will also reduce toxicity by destroying TCE and other chlorinated VOCs in situ and will directly reduce the volume of the secondary source.

3.1.2.2 Compliance with Applicable or Relevant and Appropriate Requirements. Appendix C, Table C-1, describes how the ISB system will comply with the substantive portions of the regulatory requirements.

Table 3-1. Summary of Applicable or Relevant and Appropriate Requirements for the hot spot remedy.

Requirement (Citation)	ARAR Type: Action Specific	ARAR Type: Chemical Specific	ARAR Type: Location Specific	Status: Deleted	Status: Unchanged	Remedy: Hot Spot	Comments
RCRA and Hazardous Waste Management Act							
Generator Standards IDAPA 58.01.05.006 (formerly IDAPA 16.01.05.006)	X				X		
Hazardous Waste Determination (40 CFR 262.11)	X				X	A	
General Facility Standards IDAPA 58.01.05.008 (formerly IDAPA 16.01.05.008)	X		X		X		
General Waste Analysis (40 CFR 264.13)	X				X	A	
Preparedness and Prevention (40 CFR Subpart C, 264.31–.37)	X				X	A	
Closure Performance Standard (40 CFR 264.111)	X				X	A	
Disposal/Decontamination (40 CFR 264.114)	X				X	A	
Use/Management of Containers (40 CFR 264, Subpart I)	X				X	A	
Land Disposal Restrictions (IDAPA 58.01.05.011 [formerly IDAPA 16.01.05.011])	X				X	A	
RCRA, Section 3020	X	X			X	A	
Underground Injection Control							
Idaho Rules for the Construction and Use of Injection Wells (IDAPA 37.03.03)	X	X			X	A	
Idaho Public Drinking Water							
MCLs (numerical standards only) (IDAPA 58.01.08.050.02 and .05 [formerly IDAPA 16.01.08.050.02 and .05])		X			X	R	
To-Be-Considered							
Radiation Protection of the Public and the Environment (DOE Order 5400.55)	X				X	A	Worker protection standard applies to workers only

Key: A = applicable requirement
R = relevant and appropriate requirement

4. REMEDIAL DESIGN

This section discusses the basis for and key aspects of the remedial design. A separate remedial design document, the "In Situ Bioremediation Remedial Design, Test Area North, Operable Unit 1-07B (Draft)" (DOE-ID 2002a), provides the design specifications, drawings, and supporting information.

4.1 Technical Basis

The technical basis identifies the operations and performance requirements necessary to prepare the ISB design. The requirements are established to bracket the key operating and monitoring parameters that are necessary for the ISB system to achieve the RAOs. The technical basis for the design consists primarily of the 3 years of operational data that have been collected during the field evaluation, predesign phases, and predesign operations. The overall objective of this RD/RA process is to design and construct a cost-effective electron donor injection and monitoring system and to develop an efficient operating strategy that will meet or exceed the RAOs.

4.1.1 Problem Statement

A variety of liquid waste and sludge were injected into approximately the upper 30 m (100 ft) of the Snake River Plain Aquifer at TAN using well TSF-05 for nearly 20 years ending in 1972. As a result of this injection history, a significant quantity of residual material remains in the vicinity of TSF-05. This residual material is commonly referred to as the "secondary source." The following subsections describe the hydrologic setting for the residual source area, the composition and distribution of the residual source material, and the chronology of events that lead up to the design of ISB.

4.1.1.1 Residual Source Area Hydrologic Setting. The aquifer in the vicinity of TSF-05 is somewhat less transmissive than the INEEL average. The Site conceptual model indicates that transmissivities in this area range from about 38 m^2/day (409 ft^2/day) to 3,250 m^2/day (350,000 ft^2/day), as compared to an INEEL mean of about 8,640 m^2/day (93,000 ft^2/day) (USGS 1991). The hydraulic gradient near TSF-05 is approximately 0.0002 m/m to the east-southeast (EG&G 1994 and INEEL 1999a). The direction of groundwater flow and transport in the contaminated aquifer near TSF-05 is easterly and it appears to be governed by at least four key features. These features include (1) recharge from the TSF-07, disposal pond, (2) pumping at the TAN production wells, (3) a general area of low hydraulic conductivity south of TSF-05 (discussed in INEEL 1996a and INEEL 1999b), and (4) the regional southerly gradient.

The velocity of groundwater throughout the plume is probably best estimated by the numerical model calibration to tritium transport. The average estimated groundwater velocity was about 0.15 m/day (0.49 ft/day) for most of the plume. This is consistent with an estimate of 0.13 m/day (0.43 ft/day) (EG&G 1994) (based on evidence for the travel time during operation of the injection well) from injection well TSF-05 to Well USGS-24. However, the model estimated a slower groundwater velocity of 0.073 m/day (0.24 ft/day) in the upgradient portion of the plume near the source area.

On the plume scale, the effective porosity of the aquifer has been estimated to be about 3%, again through numerical model calibration to the tritium plume (Ackerman 1991). This value is about half that observed in a similar, large-scale characterization effort at the INEEL (INEEL 1997b), but like the comparatively low transmissible at TAN, this may be a result of the advanced age of the basalt. Not surprisingly, the effective porosity in the immediate vicinity of TSF-05 is much lower because of the well's injection history, as discussed in the next two sections.

4.1.1.2 *Residual Source Composition.* During the early groundwater characterization activities at TAN, it was found that sludge occupied the bottom 17 m (55 ft) of the TSF-05 well casing (EG&G 1994). The sludge was removed from the well in 1990 and sampled. The analytical results for the constituents of greatest interest to this work are summarized in Table 4-1 (EG&G 1994). Trichlorethene (TCE) was measured at 30,000 mg/kg, or 3% by weight. Though tetrachloroethylene (PCE) and dichloroethene (DCE) were at lower concentrations than TCE, they were still significant contaminants. Also of interest are the concentrations of the radionuclides. Two gamma emitters, ^{60}Co and ^{137}Cs, were both present in the sludge at significant activity levels. Their presence was useful as a tracer of the sludge distribution.

Table 4-1. Contaminant concentrations in TSF-05 sludge from 1990.

Contaminant	Concentration
TCE	30,000 mg/kg
PCE	2,800 mg/kg
1,2-DCE	410 mg/kg
^{60}Co	812 pCi/g
^{137}Cs	2,340 pCi/g
Tritium	1.03×10^6 pCi/L

The high concentrations of tritium (almost 20 years after use of the injection well ceased) are particularly interesting considering that tritium should move freely through the subsurface as water. Tritium has never been measured outside of TSF-05 at concentrations greater than the drinking water standard of 20,000 pCi/L, despite concentrations in the sludge almost two orders of magnitude higher. This disparity suggests that the tritium is trapped in the sludge pore water where advective groundwater flow is insignificant. Thus, tritium can only move downgradient after diffusing from the sludge pore water to the nearest advective flow path. This point is important because it must be true not only of tritium but also of all other contaminants in the sludge. Of course, most other contaminants are also subject to sorption within the sludge, so their migration out of the sludge is further retarded. For the purpose of illustration, the sludge in the formation around TSF-05 can be thought of as a sponge saturated by the contaminants that are only very slowly released to groundwater flowing past.

4.1.1.3 *Secondary Source Distribution.* The sludge in the formation around TSF-05 is the secondary source that continues to contaminate groundwater at TAN. An important step in the characterization of the site for remediation is to estimate the distribution of the secondary source. For ISB to meet the RAOs, the electron donor must be distributed throughout the volume of aquifer containing residual source material. The association of the gamma-emitters (^{60}CO and ^{137}Cs) with the sludge provides a means for using existing wells to estimate the residual source distribution. Downhole natural gamma and gamma spectroscopy logs were performed to establish the distributions of these radionuclides, using them as an indicator of the sludge distribution (INEEL 1998).

The gamma logging data illustrated several important points. First, the logging data showed the spatial extent of elevated gamma activity (see Figure 4-1). Observed ^{60}Co and ^{137}Cs activity extended as far as Well TAN-D2, about 35 m (115 ft) northwest of TSF-05. Logging of TAN-37, 40 m (130 ft) east of TSF-05, did not show elevated gamma activity. The second important result of these activities was the observation that the depths of elevated gamma activity correlated among the wells with high porosity zones identified through seismic tomography (INEEL 1998). This indicated that the layered geological structure did, in fact, result in preferential subhorizontal flow paths for the sludge away from the TSF-05. Finally, it was observed that elevated gamma activity was only present to about 91 m (300 ft) below land surface (bls), which is approximately the bottom of the TSF-05 injection interval. The residual source, therefore, appears to exist primarily in the upper 30 m (100 ft) of the aquifer.

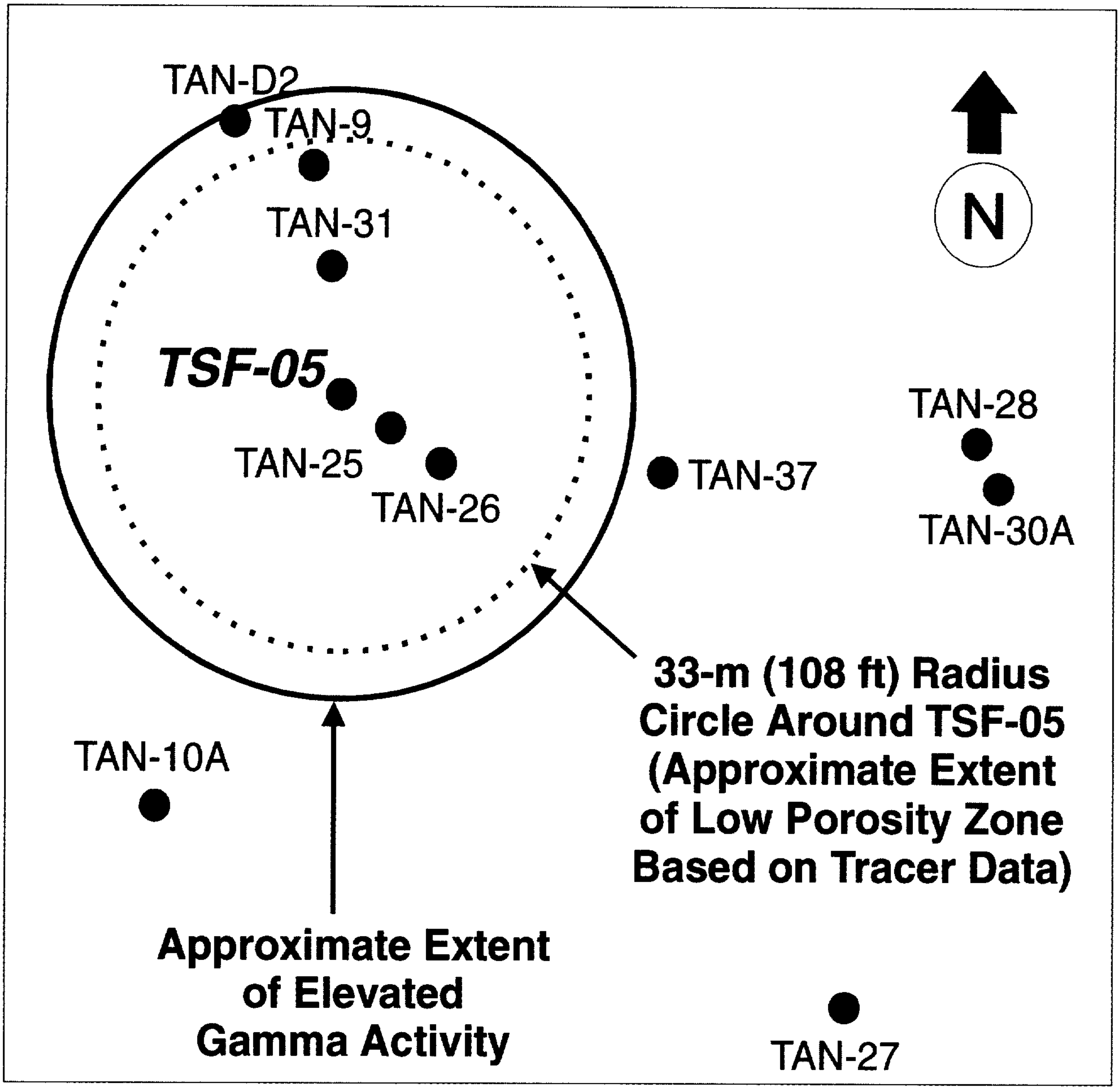


Figure 4-1. Approximate extent of the residual source around TSF-05.

The spatial extent of the sludge comprising the secondary source of contamination can also be estimated based on differences in the hydrologic properties of the aquifer in the vicinity of TSF-05. A numerical model of the TSF-05 area was developed through inverse modeling of multiple-well pumping tests (INEEL 1998). The effective porosity within about 20 m (66 ft) of TSF-05 was calibrated to range between less than 0.05 and 0.1%. The effective porosity in the bulk of the model domain was closer to 1%. The large reduction of effective porosity around TSF-05 is almost certainly a result of clogging of the formation by sludge (residual source material).

Finally, as part of the bioremediation field evaluation (Section 4.1.2.1), a diverging tracer test was performed (using TSF-05 as the injection point) that provided data useful for estimating the extent of the aquifer with reduced effective porosity as a result of the sludge. Two models were applied to the data to estimate effective porosity near TSF-05. Both models revealed very low effective porosities ranging from 0.04 to 0.1% within 15 m (50 ft) of TSF-05, and increasing porosities with distance (Sorenson 2000). These results are consistent with significant plugging of the formation with sludge near TS-05 that decreases with distance from the well. A bull's-eye model was developed to estimate the distance from TSF-05 at which the porosity transition occurs, and hence the radial extent of the sludge. Based on that simple model, the sludge extent was estimated to reach about 29 to 30 m (95 to 100 ft) from TSF-05 (see Figure 4-1) (Sorenson 2000).

4.1.1.4 Chronology of Events. In 1995, a ROD was written with a requirement to conduct treatability studies that focused on specific technologies that offered the potential to be more cost effective than the original remedy of pump-and-treat. These technologies included Metal Enhanced Reductive Dehalogenation, Monolithic Confinement (Grouting), ISB, In Situ Chemical Oxidation, and MNA. The treatability studies were concluded in 1999 and the results are summarized in the Field Demonstration Report (DOE-ID 2000a). The Field Demonstration Report presented field-monitoring data, which demonstrated that the ISB technology evaluation met or exceeded all objectives and expectations. The technical success of the field evaluation, combined with the preliminary cost information, supported a recommendation to implement ISB for remediation of the hot spot. Therefore, in 2001 a ROD amendment was written that selected ISB to replace pump-and-treat for the hot spot area.

Beginning with the initial field evaluation, ISB activities leading up to this RAWP provide important information for implementing the final remedy. For purposes of this discussion, all of these activities are referred to as predesign operations. These activities are summarized in several documents, including (1) the *Field Evaluation Report of Enhanced In Situ Bioremediation, Test Area North, Operable Unit 1-07B* (INEEL 2000), (2) the *Operable Unit 1-07B In Situ Bioremediation Annual Performance Report for October 1999 to July 2001* (INEEL 2002a), (3) *Effects of Alternate Donors on an Enrichment Culture Capable of Complete Reductive Dechlorination (Draft)* (INEEL 2002b), and (4) the *TAN OU 1-07B ISB Groundwater Model Development and Initial Performance Simulation* (INEEL 2002c).

4.1.2 Predesign Operations

In order to design a cost-effective, long-term bioremediation system for the hot spot, information was collected during predesign operations to address several key issues. The information collected was in the form of answers to the following questions:

- What electron donor should be used to stimulate anaerobic reductive dechlorination (ARD)?
- How much electron donor should be added and how frequently should the electron donor be injected?
- Where should the electron donor be injected?
- At what rate should the electron donor be injected?

The field evaluation, together with the subsequent activities, provides over 3 years of experience to address the key issues. This section summarizes the results of these operations in the context of the design issues, as well as some additional laboratory studies and numerical modeling that contribute important insight to a cost-effective, long-term bioremediation system design.

4.1.2.1 Field Evaluation. A field evaluation was conducted to determine whether degradation of TCE could be enhanced through the addition of an electron donor (lactate). The ISB field evaluation at

TAN entailed the weekly injection of high concentrations of lactate solution into the injection well, TSF-05, for a period of 8 months. In order to control the distribution of lactate and nutrients in the subsurface, it was desirable to induce a hydraulic gradient through pumping. An extraction well, TAN-29, was pumped continuously throughout the field evaluation to induce flow along the axis of the TCE plume where the highest concentrations of the lactate were present. The goal was to create an ARD treatment cell between Wells TSF-05 and TAN-29.

A start-up period was used to establish the baseline for relevant parameter distributions and to establish the baseline for flow and transport in the aquifer under the conditions of the field evaluation. Groundwater monitoring to collect the data supporting field evaluation objectives began once the start-up period was completed, the necessary adjustments were made to the operations strategy, and lactate was injected into Well TSF-05.

The weekly injections of lactate into Well TSF-05 during the field evaluation phase resulted in high concentrations of the electron donor in source area and deep wells. The electron donor was present mainly in the form of propionate and acetate, which were present in a stoichiometric ratio greater than one, indicating significant lactate fermentation and some propionate fermentation. These high concentrations of electron donor resulted in the rapid depletion of competing electron acceptors. Sulfate reduction was observed almost immediately and methanogenesis was observed in source area wells after approximately 4 months. Complete ARD of TCE to ethene was observed in source area wells coincident with the onset of methanogenesis. The electron donor was not distributed beyond the source area in the upper part of the aquifer and, for this reason, redox conditions remained only mildly reducing. Anaerobic reductive dechlorination was not observed in downgradient or wells more than 15 m (50 ft) crossgradient (INEEL 2002a).

The field evaluation demonstrated that complete reductive dechlorination of TCE to ethene could be achieved through electron donor addition. Furthermore, the process resulted in accelerated mass transfer of TCE from the secondary source, which may shorten the overall remedial time frame relative to the default remedy, pump-and-treat.

Following the field evaluation, new objectives were identified and broken down into predesign phase (PDP-I), PDP-II, and predesign operations (PDO). These data were then used to develop a plan for long-term implementation of enhanced ISB at the TAN hot spot.

4.1.2.2 Predesign Phase-I. Predesign Phase-I was established to determine the persistence of the electron donor and ARD reactions once lactate injections were discontinued, and to evaluate the efficiency of ARD reactions in the prolonged presence of electron donors other than lactate. Lactate injection was discontinued while changes in the treatment cell were monitored. Operations consisted simply of monitoring biogeochemical changes for a period of 4 months and monitoring VOCs throughout the treatment cell.

When lactate injections were discontinued during PDP-I, electron donor concentrations throughout the source area decreased rapidly. At the same time, the propionate:acetate decreased, as propionate fermentation was the dominant electron donor utilization process. The electron donor in deep wells began a slow decline. Redox conditions remained methanogenic in the source area and deep wells and conditions in downgradient wells became more reducing. The efficiency of ARD reactions increased during this time, as indicated by the complete depletion of TCE and increase in ethene concentrations (INEEL 2002a).

Data collected indicated that the efficiency of ARD reactions increased when propionate and acetate, rather than lactate, were available as the only electron donors. For this reason, the lactate injection strategy was changed from that used during the ISB field evaluation. Larger volumes of lactate were injected on a much less frequent basis (bimonthly rather than weekly), and the increased injection volume caused the electron donor solution to be pushed farther out into the treatment cell. The injection of lactate resulted in rapid fermentation to propionate and acetate, which was then utilized much more slowly than lactate. The infrequent injection of lactate allowed the more slowly utilized propionate and acetate to be the dominant electron donors within the treatment cell, favoring more efficient ARD.

4.1.2.3 Predesign Phase-II. Predesign Phase-II, which began in January 2000 and continued through April 2001, was established for the following reasons:

- To determine the effect of renewed lactate injection (after approximately 4 months without lactate injection) on ARD efficiency and redox conditions throughout the treatment cell. The treatment cell is defined as the biostimulated aquifer volume of enhanced ARD.
- To optimize lactate addition (quantity and frequency) based on data collected from PDP-I.
- To monitor concentrations of regulated substances in electron donor stock solutions.

When lactate injections were resumed on a bimonthly basis in PDP-II, the electron donor concentrations and the propionate:acetate ratio increased in source area wells with each injection, while deep wells remained unaffected. Source area wells remained methanogenic; however, conditions in downgradient wells became less reducing. Anaerobic reductive dechlorination continued in source area wells, while a slight rebound in TCE and depletion of ethene in downgradient wells indicated that the areal extent of ARD reactions had decreased since lactate injections were renewed during PDP-II.

The data collected indicated that, in most of the residual source area, the efficient ARD observed in PDP-I was maintained during PDP-II. It also showed that the efficiency at the downgradient edge of the residual source had decreased somewhat, apparently because of incomplete electron donor delivery to this area. The downgradient portion of the residual source area required better lactate distribution.

The electron donor product used during PDP-II was monitored for regulated substances, had the lowest trace metal concentrations measured to date, and met all requirements. Concerns about EPA Target Analyte List metals in sodium lactate have been addressed by requiring analysis of each new source and product type.

4.1.2.4 Predesign Operations. The results observed from PDP-I and -II were used to define the specific approach to be used to meet the following objectives for PDO:

- Continue to operate the ISB system to contain and degrade the OU 1-07B hotspot
- Maximize cost-effectiveness of TCE dechlorination
- Optimize sampling frequency and location
- Determine whether lactate injection results in mobilization of metals, strontium, or semivolatile organic compounds from the secondary source
- Determine how to distribute the electron donor better within the upper part of the aquifer.

These following objectives were met:

- The ISB system continued to contain and degrade the hotspot, as evidenced by TCE concentrations near nondetect in hotspot wells. Trans-DCE was observed to be more recalcitrant to degradation; however, concentrations are approximately equivalent to MCLs at the end of the treatment cell and decrease downgradient because of attenuation and dispersion.

- The PDO injection strategy resulted in propionate fermentation conditions preferred for efficient ARD in source area wells. The downgradient secondary source area shows incomplete dechlorination. Alternate injection strategies are required to optimize dechlorination in the downgradient residual source area.

- The sampling strategy was refined based on results to date. Fewer locations are monitored for source mobilization parameters; analytes and sampling frequency are reduced overall. Current strategy cost-effectively meets all requirements.

- No significant mobilization of metals or semivolatile organic compounds was observed. Only ^{90}Sr appears to be mobilized in the immediate source area.lactate injection resulted in no significant mobilization of ^{90}Sr, metals or semivolatile organic compounds outside the ISB treatment cell.

- The current injection strategy maintains adequate electron donor in the upper aquifer in most of the secondary source area. However, alternate injection locations and strategies to achieve this goal in the downgradient residual source area are required to distribute electron donor between TAN-25 and TAN-37.

4.1.2.5 Numerical Modeling. Numerical modeling was recently performed to evaluate two model scenarios to assist in designing an optimum remediation strategy (INEEL 2002c). Scenario 1 was designed to inject the same mass of lactate at TSF-05 as that injected during PDP-II, but with about twice the volume of water. In other words, the injected lactate concentration was about half that of the PDP-II injections. Scenario 2 involved an injection simultaneously with the injection at TSF-05 at a hypothetical well located just west of TAN-37. The purpose of Scenario 2 was to gain insight into methods of distributing the electron donor over a much larger area. The model results indicated that a higher volume lactate injection causes a distribution similar to that resulting from previous injections, while using two injection wells offers a much better donor distribution than a single injection well.

4.1.2.6 Laboratory Studies. During FY-01 and FY-02, a laboratory study was performed to determine the effectiveness of other readily available, lower-cost carbon sources—specifically whey and molasses (INEEL 2002b). Whey and molasses could potentially stimulate microbial dechlorination of TCE similarly to lactate. This study assessed the effectiveness of whey and two different grades of molasses by utilizing them in fed-batch reactor studies in which dechlorination daughter products and organic acids were measured. The data were then used to evaluate dechlorination efficiencies of the various electron donors.

The study revealed that lactate stimulated the most rapid complete dechlorination. Whey showed the next-best efficiency, followed by food grade molasses. The feed grade molasses was the only carbon source that did not facilitate dechlorination of TCE and PCE.

4.1.2.7 Summary of Important Topics. The following list summarizes the hydrologic setting for the secondary source area and its composition and distribution, as described above:

1. The Snake River Plain Aquifer has transmissivities ranging from about 38 m^2/day (409 ft^2/day) to 3,250 m^2/day (350,000 ft^2/day).

2. The direction of groundwater flow and transport in the contaminated aquifer near TSF-05 is easterly.

3. The hydraulic gradient near TSF-05 is approximately 0.0002 m/m to the east-southeast.

4. The estimated groundwater velocity is 0.073 m/day (0.24 ft/day) in the upgradient portion of the plume near the source area.

5. Modeling of pumping and tracer test results revealed very low effective porosities ranging from 0.04 to 0.1% within 15 m (50 ft) of TSF-05, and increasing porosities with distance.

6. The residual source appears to exist primarily in the upper 30 m (100 ft) of the aquifer and the extent of the sludge was estimated to be about 29 to 30 m (95 to 100 ft) radially from TSF-05.

The following list summarizes the information collected during PDO that will aid in designing a cost-effective, long-term bioremediation system for the hot spot:

1. **What electron donor should be used to stimulate anaerobic reductive dechlorination?** Field results indicate that lactate is an effective electron donor. Laboratory studies performed to test alternate electron donors revealed that lactate stimulated the most rapid complete dechlorination. After lactate, whey showed the next best efficiency, followed by food grade molasses. Additional work will be required to determine the most cost-effective of these or other potential electron donors.

2. **How much electron donor should be added and how frequently should the electron donor be injected?** The electron donor injection strategy for long-term operations should consist of larger volumes of lactate injected on a much less frequent basis than weekly (i.e., monthly or bimonthly). Numerical modeling suggests that higher-volume, lower-concentration lactate injections are about the same as the PDP-II injections in terms of electron donor distribution. If another electron donor is used, then the volume, concentration, and frequency will need to be reestablished.

3. **Where should the electron donor be injected?** Field results indicate that alternative injection strategies to deliver the electron donor to the outside edge of the secondary source area are required. Numerical modeling suggests that at least one additional injection location is necessary to provide adequate electron donor distribution to the downgradient portion of the residual source area

4. **At what rate should the electron donor be injected?** Predesign operations activities did not include an evaluation of different electron donor injection rates; however, current rates appear to be adequate.

All the information described in this section was utilized to establish the TFRs for the ISB electron donor system.

4.2 Technical and Functional Requirements

The specific requirements for the ISB amendment addition system (or the electron donor system) are located in TFR-2539, "Technical And Functional Requirements for the In Situ Bioremediation Design at TAN, OU 1-07B." In general, the ISB amendment addition system will be comprised of equipment and controls needed to properly inject an electron donor within the OU 1-07B hot spot area. This ISB system, working in conjunction with naturally occurring organisms, is designed to degrade the secondary source within the hot spot and stop contaminants from leaving the hot spot. The ISB amendment addition system will add amendment to the current injection location (TSF-05) but will be capable of expanding to other injection locations. These additional injection locations will be existing wells or may be new wells. New wells will be installed in incremental stages and will only be installed when deemed necessary through project review of operational data. The ISB amendment addition system will mix the amendment with potable water and inject the mixture into the wells.

The technical and functional design requirements used are listed as follows:

- In order to perform year-round operations and injections, storage for the amendment to prevent physical, chemical, or biological degradation must be provided. The amendment must also be brought to its operating temperature prior to mixing. Proper heating, ventilation, and air conditioning is required to maintain adequate working conditions year-round for operators in the ISB manual injection system.

- In situ bioremediation groundwater monitoring must be capable of detecting changes in the subsurface plume to determine the adequacy of the source containment and its removal. Figure 4-2 identifies the existing monitoring wells plus the location of two potential new monitoring wells (PMW-1 and PMW-2). As with any new injection well, the new monitoring wells would be installed in incremental stages and will only be installed when deemed necessary through project review of operational data.

- The ISB system will require a field sample analysis laboratory equipped with the proper instruments to perform several real-time field analyses of groundwater samples taken as part of the ISB monitoring process.

- The ISB amendment addition system will be designed to operate for 15 years in order to meet the RAOs for the hot spot remediation, as defined by the ROD amendment (DOE-ID 2001a). The ISB amendment addition system's primary operations include, but are not limited to the following:

    - Staging an adequate supply of amendment

    - Pumping the amendment into the distribution system

    - Monitoring the distribution of amendment

    - Monitoring the performance of ISB with respect to meeting regulatory requirements.

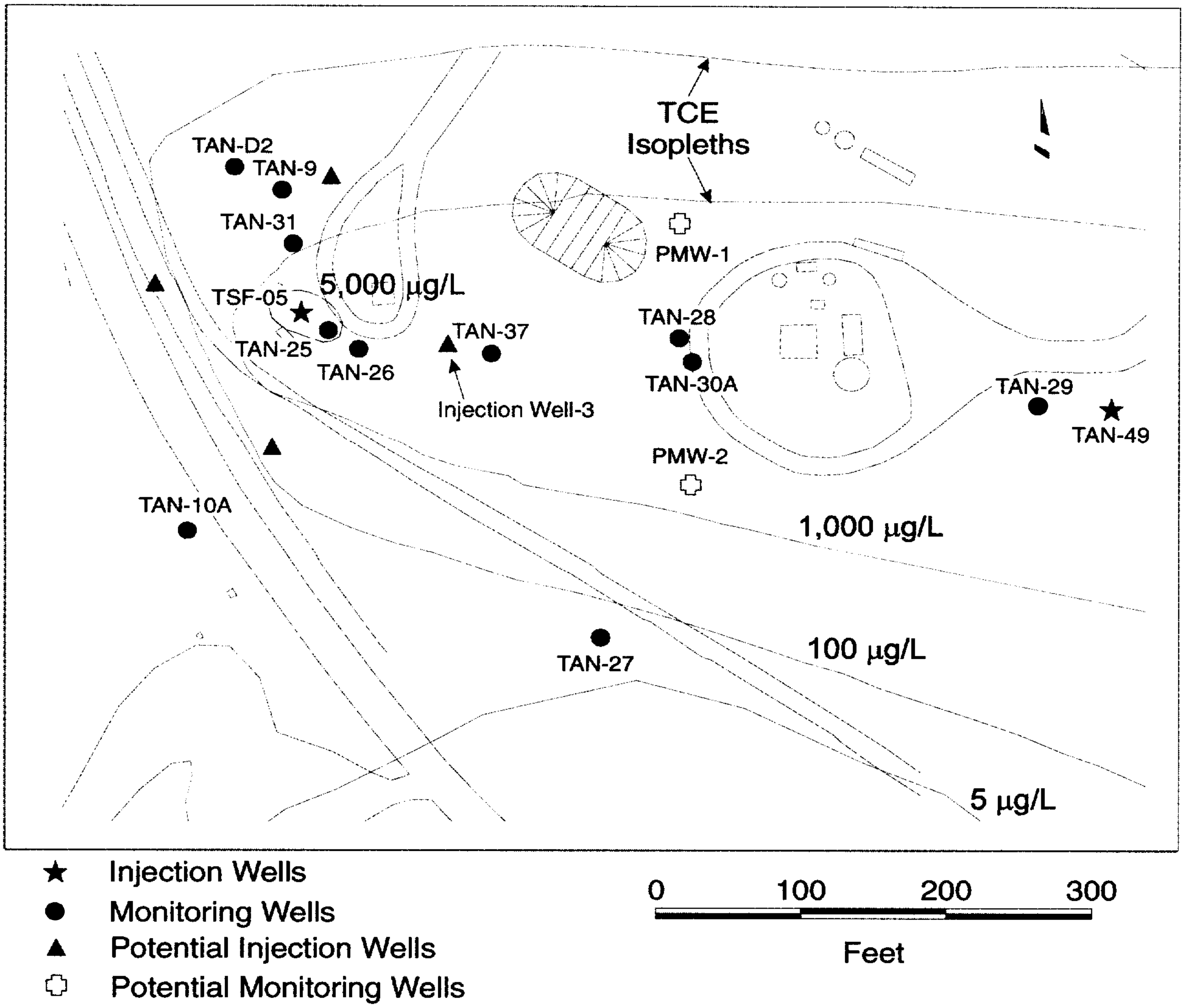


Figure 4-2. Hot spot vicinity map.

In situ bioremediation system assumptions include the following:

- Multiple injection locations are required to obtain an effective amendment distribution
- Water and electric utilities will be available; however, no sewer and communications services will be available
- Support personnel (e.g., crafts, Industrial Hygiene, and Radiological Control Technicians) will be available to support ISB long-term operations
- The ISB system shall be designed to operate a minimum of 15 years and will be capable of operating longer following a retrofit. The longer operational period would be necessary if ISB cannot achieve RAOs within 15 years.

4.3 Infrastructure Design Alternatives

This section discusses the facility design options available to the project resulting from the completion of the ISB TFRs. The previous section summarized the ISB hot spot TFRs and assumptions. TFR-2539 provides a complete breakdown of the recommended TFRs. These requirements and assumptions have led to the development of several alternative strategies for design and construction of the ISB Hot Spot Facility. These alternatives were developed to consider and compare the capital and long-term operations costs and to identify the most desirable alternative to maximize ISB effectiveness while maintaining project schedule, quality, and cost objectives.

Initially, more than a dozen alternatives were identified that considered such items as facility size, location, storage capability, the use of existing facilities, field lab space, number of injection wells needed, and the use of electron donors. The minimum capability requirements for the above-referenced alternatives are as follows:

- Three injection wells
- Injection in one well at a time
- Lactate, molasses, and whey handling capability.

Following the review of these alternatives with the Agencies and further internal analysis, the alternative list was narrowed to seven and is presented in Table 4-2. As a result of further reviews and discussions with the Agencies, Alternative C was chosen for implementation of ISB at the hot spot. Table 4-3 is a comparison of the seven alternatives considering capital construction cost. The comparison is made of facility construction and long-term operation cost for lactate versus whey powder for each alternative. For both lactate and whey powder, the ROD Cost Estimate Net Present Value before contingency is used as the base cost.

Alternative C features the minimum requirements listed above and includes space in the new facility for a field laboratory and field personnel office space. The more expensive alternatives were ruled out because it is currently believed that the capability to simultaneously inject in multiple wells will not be a requirement, and, therefore, the cost of sizing a facility to store sufficient amendment and piping to multiple wells can be avoided. Less expensive alternatives (other than Alternate C) were eliminated because of the long-term nature of the project (a minimum design life of 15 years). The less expensive alternatives relied on utilizing trailers or existing TAN facility buildings for storage, lab space, and office space. TAN facilities are scheduled for deactivation, decontamination, and decommissioning (D&D&D) beginning in FY-03. Operable Unit 1-07B personnel will not be able to use existing TAN facilities after that time. Based upon the uncertainty of the TAN mission and the potential costly maintenance costs for trailers and temporary facilities, these alternatives were ruled out.

4.4 In Situ Bioremediation Infrastructure Design

This section presents a summary discussion of the ISB hot spot design. A much more detailed discussion of this design, including drawings, specifications, and justifications, is provided in the "In Situ Bioremediation Remedial Design, Test Area North, Operable Unit 1-07B (Draft)" (DOE-ID 2002a). The new facility is located adjacent to the existing groundwater treatment facility just downgradient from the hot spot (see Figure 4-3). This section focuses on the two primary components(1) the process facility and (2) the laboratory facility.

Table 4-2. Alternative evaluation for design and construction of the in situ bioremediation Hot Spot Facility.

Alternatives	Cost of Support Facilities	Cost of Wells	Number of Injection Wells	Number of Simultaneous Injections	Whey Powder	Molasses/ Sodium lactate	Heated Nutrient Storage	Office	Rest Rooms	Lab	Laboratory Equipment Storage (ft^2)	Sampling Equipment Storage (ft^2)	Year-Round Injections	Bldg	Piping	Simultaneous Injections (potable water)	Whey Powder	Molasses/ Sodium Lactate	Rest Rooms	Trailer	Tanker Delivery
A) 2,400 ft^2 (60' x 40') 5 Injection Wells 3 Simultaneous Injectors Molasses/Lactate/Whey New Laboratory/Office	$634k	$450k	5	3	x	x	36 275 gal. Totes/ 36 2000 lb. Sacks	x	x	x	250	180	x	414	79	22	61	41	17	0	0
**** Minimum requirements** 3 Injection Wells 1 Injection Well Only Molasses/Lactate/Whey			3	1	x	x	20 275 gal. Totes/ 20 2000 lb. Sacks	(1)	(1)	(1)	0	0	x								
A*) 2,400 ft^2 (60' x 40') 3 Injection Wells 1 Simultaneous Injector Molasses/Lactate/Whey New Laboratory/Office	$582k	$150k	3	1	x	x	36 275 gal. Totes/ 36 2000 lb. Sacks	x	x	x	250	180	x	414	49	0	61	41	17	0	0
C) 1,200 ft^2 (40' x 30') 3 Injection Wells 1 Injection Well Only Molasses/Lactate/Whey New Laboratory/Office	$380k	$150k	3	1	x	x	20 275 gal. Totes/ 20 2000 lb. Sacks	x	x	x	0	100	x	212	49	0	61	41	17	0	0
E) 800 ft^2 (40' x 20') 3 Injection Wells 1 Simultaneous Injector Molasses/Lactate/Whey Trailer for Office/Lab	$304k	$150k	3	1	x	x	20 275 gal. Totes/ 20 2000 lb. Sacks	(1)	(1)	(1)	0	100	x	145	27	0	61	41	0	30	0
G) 400 ft^2 (20' x 20') 1 40'x10' Seavan (new) 3 Injection Wells 1 Injection Well Only Molasses/Lactate/Whey Trailer for Office/Lab	$286k	$150k	3	1	x	x	36 275 gal. Totes/ 36 2000 lb. Sacks	(1)	(1)	(1)	0	0	x	127	27	0	61	41	0	30	0
N) 1 Seavan (existing) 3 Injection Wells 1 Injection Well Only Molasses/Lactate TAN-607 for Office/Lab	$167k	$150k	3	1		x		x	x	x			(2)	60	49	0	0	41	17	0	x
O) 1 Seavan (existing) 3 Injection Wells 1 Injection Well Only Molasses/Lactate Trailer for Office/Lab	$68k	$150k	3	1		x		(1)		(1)	0	0	(2)	0	27	0	0	41	0	0	x

(1) = Located in trailer
(2) = Heated tanker

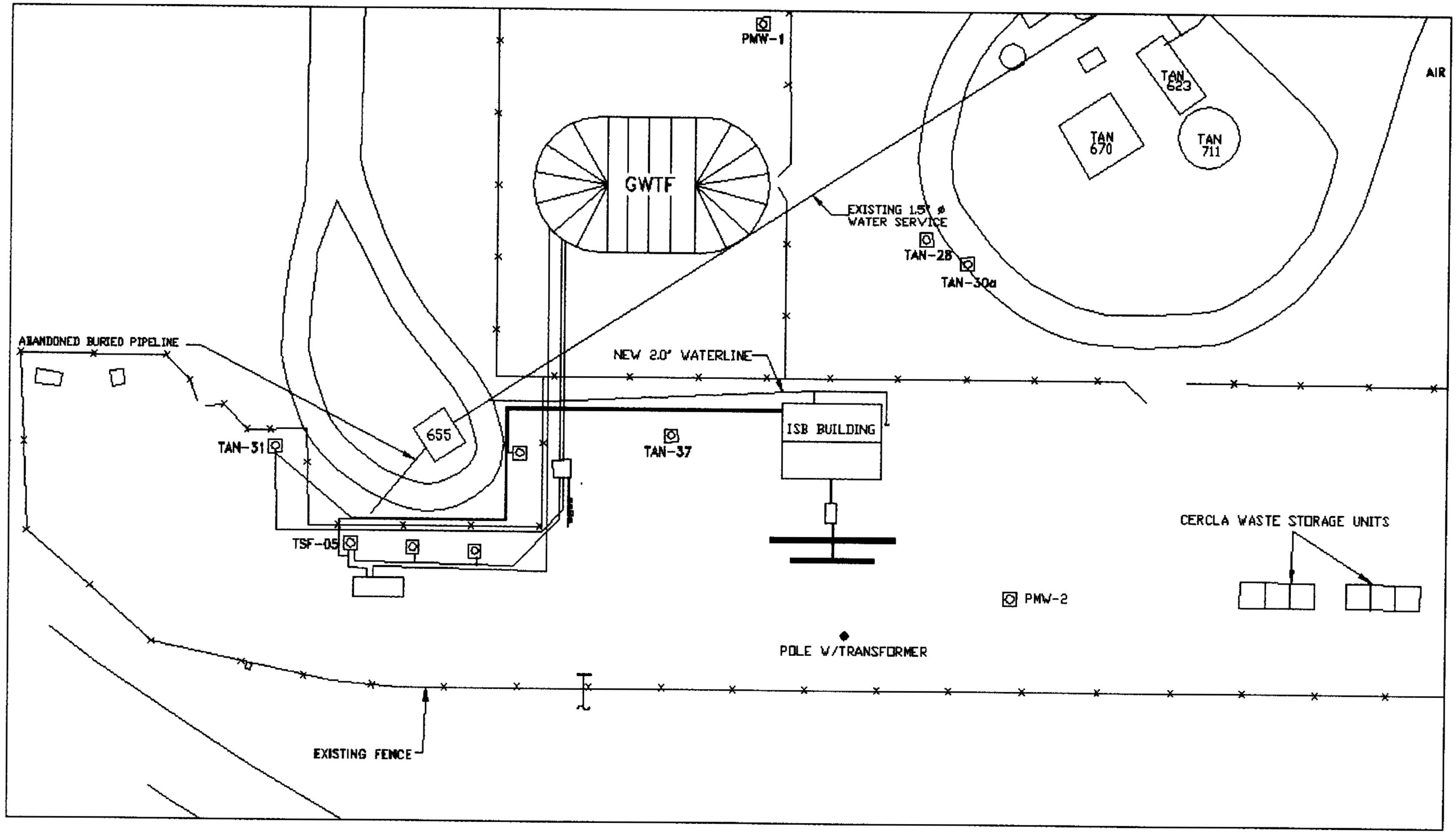


Figure 4-3. In situ bioremediation facility site area layout.

Table 4-3. Record of Decision amendment cost comparison.

	Net Project Cost (Lactate)		Net Project Cost (Whey Powder)	
	Net Present Value	Difference[a]	Net Present Value	Difference[a]
Original	$35,414,898[b]	$—	$35,414,898[a]	$—
Alternate A	$35,926,485	$511,587	$35,651,301	$236,403
Alternate A*	$35,877,785	$462,887	$35,602,601	$187,703
Alternate C	$35,687,031	$272,133	$35,411,847	$(3,051)
Alternate E	$35,615,230	$200,332	$35,340,046	$(74,852)
Alternate G	$35,598,232	$183,334	$35,323,049	$(91,849)
Alternate N	$35,485,890	$70,992	N/A	N/A
Alternate O	$35,392,370	$(22,528)	N/A	N/A

a. Relative difference of each alternative from the ROD cost estimate. The difference is in net present value.
b. ROD cost estimate for amended remedy in net present value before contingency.

4.4.1 Process Facility

The Process Facility is a 30 × 40-ft prefabricated building set onto a slab-on-grade concrete base (see Figure 4-4). Within the facility are distinct areas for nutrient storage (500 ft^2), process equipment (300 ft^2), a field laboratory (250 ft^2), and office space (150 ft^2). A 5-m (15-ft) wide roll-up delivery door provides direct access to the nutrient storage area, while an 2-m (8-ft) wide roll-up door provides easy access for off-load of used totes, supersacks, and pallets to the external storage pad during injection events. This building will be situated within the CERCLA Waste Storage Area, which is southeast of Well TAN-37. This location will facilitate quarterly delivery of palletized amendments, as well as minimize the amount of trenched piping required for solution delivery to the injection wells. Amendment solution can be injected into one of the three injection wells located within 30 m (100 ft) of TSF-05 (TSF-05, TAN-31, and Injection Well 3). The equipment used in this process is located in the process equipment area of the Process Facility and includes potable water piping, amendment injection devices (i.e., pump for molasses and lactate, bulk bag unloader, and eductor for lactose powder), flow monitoring devices (pressure gauges and flow meters), flow control valves, and solution injection piping that runs from the Process Facility to each injection well (see Figure 4-5).

4.4.2 Laboratory Facility

The ISB Remedial Design Plan view of the Process Facility, shown in Figure 4-4, includes a field laboratory that will allow groundwater analyses to be performed on-site. This laboratory will house all the equipment required for groundwater sampling support, such as a water deionization apparatus, storage refrigerators and freezers, waste carboys and tanks, a fume hood with an acid counter, a sink, at least 9 m (30 ft) of counter space, a desk and PC, and equipment storage cabinets.

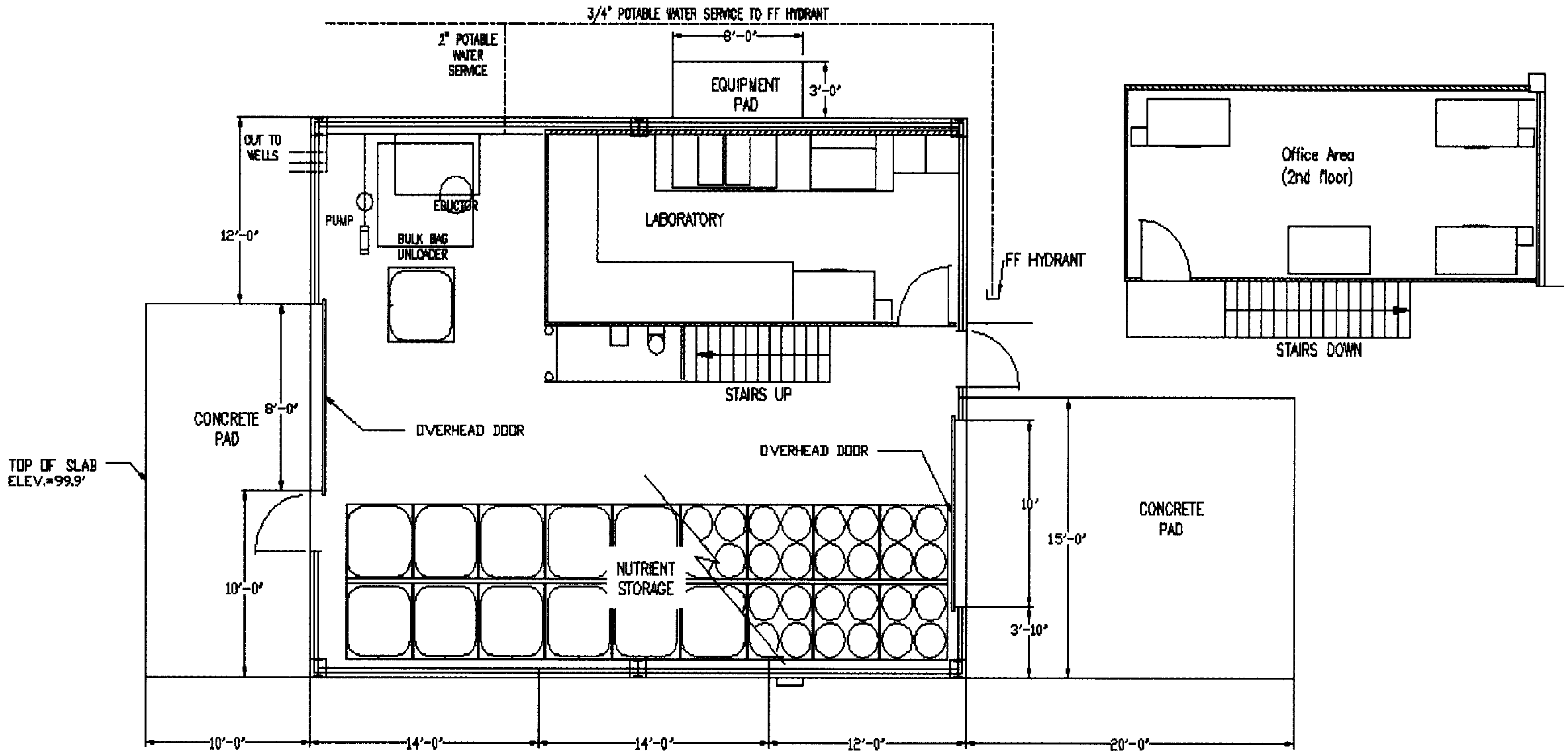


Figure 4-4. Process facility layout drawing.

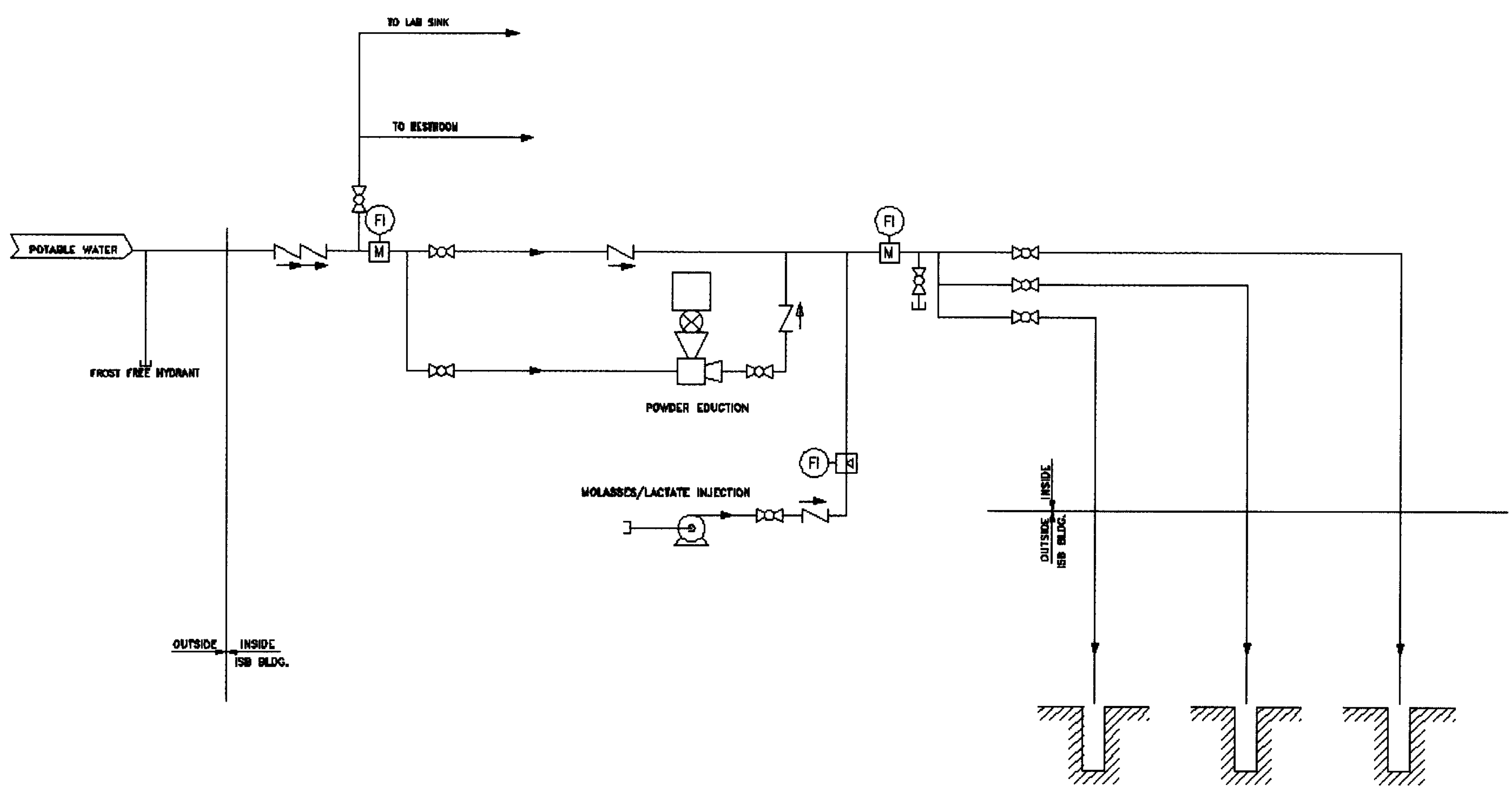


Figure 4-5. Process flow diagram for in situ bioremediation.

5. INTERIM OPERATIONS

This section addresses the requirements for the interim operations period of ISB operations. Interim operations are the period between the approval of this RAWP and the start of initial operations, which will start with the completion of construction of the new ISB Injection Facility. Interim operations will be a continuation of the predesign operational activities and will cover activities that support a better understanding of alternate amendment, development of injection and monitoring strategies that support initial operations, ISB model refinement, and continued ISB lactate addition. The *In Situ Bioremediation Operations and Maintenance Plan for Test Area North, Operable Unit 1-07B* (DOE-ID 2002b) and *Groundwater Monitoring Plan for the Test Area North Operable Unit 1-07B ISB Remedial Action* (INEEL 2002d) will govern the implementation of interim operations.

5.1 Scale-up Studies for Alternate Amendments

Two alternate amendments have been identified that may be as effective as lactate, at a much lower cost. Additional information is needed to determine if these donors are viable candidates for replacing sodium lactate. A series of scale-up studies are planned to take these donors from bench-scale to field scale. An electron donor scale-up studies work plan will be developed that details an objective approach to determine if these (or other) alternate donors can replace sodium lactate.

5.2 Injection Strategy Testing to Support Initial Operations

During interim operations, injection and monitoring strategies will be implemented that will help determine the ISB systems initial operations configuration. Field studies will be performed to determine required quantities, locations, frequency, and rates of injection and will be supported by monitoring and analysis.

5.3 In Situ Bioremediation Numerical Model Refinement

A numerical model has been developed for ISB using field data from current and previous years. This model has been tested with several simulations and was used to support ISB design assumptions. Yearly updates to the model, based on operational data, are planned. The updated model will be used both to evaluate various potential improvements to the electron donor injection strategy and to support analysis of performance monitoring data. Following refinement during the interim operations period, the model will be used to support the first ISB annual report, which incorporates new data each year.

5.4 Continued Sodium Lactate Addition

This activity consists of continued operation and maintenance (O&M) of the current ISB system, including groundwater monitoring and injection strategy evaluations.

6. FACILITY CONSTRUCTION

This section addresses the procurement, construction, and agency acceptance of the new ISB Hot Spot Injection Facility. This includes organization, subcontracting plans, construction, construction close-out, system operational testing, and agency inspections and acceptance.

6.1 Organization

The organizational structure of this remedial action must be flexible in order to handle the maturing and changing nature of the project as it goes from cradle to grave. Initially, the project will be undergoing construction and numerous operational and monitoring requirement changes as the project moves to achieve long-term operations. Throughout this period, the Agencies and the project team will be exploring methods to maximize operational efficiency, including determining the best electron donor type, quantity, injection rate, concentration, and a host of other operational and monitoring parameters. As the remedial action proceeds through operational phases, it should reach a fairly routine operational state requiring only minor modification to the operational strategy and monitoring requirements.

Throughout the project, the DOE-ID project remediation manager will be responsible for notifying the EPA and IDEQ of project activities, and will serve as the single interface point for all routine contacts between the Agencies and the management and operating (M&O) contractor. The M&O contractor shall be responsible for implementation of the remedial action from cradle to grave. This includes design, field activities, waste management, health and safety, quality assurance, and all other tasks necessary for the completion of this remedial action. The *Test Area North Operable Unit 1-07B Final Groundwater Remedial Action Health and Safety Plan* (INEEL 2002e) includes the near-term project organizational chart and a role and responsibility description. This organizational chart covers operations up through at least the initial operations phase of the project and may be adjusted from time to time, as circumstances dictate.

6.2 Subcontracting Plan

Short-term construction activities will be accomplished primarily through subcontracting. To the largest extent practicable, the work will be combined into a single bid package that will be competitively bid and awarded as a firm, fixed-price contract to the lowest price qualified bidder (subcontractor). The request for proposal will specify, among other things, a strict period of performance, which will correspond with the overall project schedule.

6.3 Construction

The construction work for this remedial action consists of four primary components, as follows:

- Process facility enclosure—A steel building with a concrete foundation capable of housing the process system, nutrient storage, and field laboratory
- Process system—A process system shall be installed that is capable of injecting electron donor within the parameters specified in the ISB TFRs
- Injection and monitoring wells—Injection and monitoring wells will be installed in accordance with project plans and specifications

- Field laboratory—A field laboratory shall be installed that provides the capability of analyzing the parameters specified in the ISB GWMP (INEEL 2002d).

Section 4 provides a more detailed discussion of these components. The construction work will be implemented through five stages, as follows:

1. Premobilization—This period of time shall be utilized to prepare the subcontractor, site personnel, and support personnel for facility construction. This will include submittal and approval of vendor data, subcontractor work plans, bonds, insurance certifications, and other necessary contractual requirements.

2. Mobilization—This period of time will be used to prepare for construction activities. This work generally includes the implementation of required administrative and engineering controls. These include health and safety controls, fences, signs and postings, demarcation of contamination and decontamination zones, establishing lay-down areas and staging areas, delivery and storage of construction materials and equipment, and set-up of field offices.

3. Construction—This period covers the installation of the four primary components.

4. Construction Completion and Closeout—Upon completion of the construction, the subcontractor and contractor shall perform a facility walkdown and develop a punch list to record deficient items. The walkdown will also include a test of individual components to determine that they were constructed and operate in accordance with design specifications. The subcontractor shall be given a limited amount of time to correct deficient items.

5. Demobilization—After construction activities and inspections have been satisfactorily completed and all equipment is properly decontaminated and cleaned, the subcontractor will demobilize from the construction site.

6.4 Start-up and Operational Testing

System operational testing will be performed on all system components to ensure that the equipment has been properly installed and operates in accordance with the design specifications. System operational testing will be performed in accordance with written start-up and test procedures. The required procedures are identified in the ISB O&M Plan (DOE-ID 2002b).

Concurrent with operational testing, the M&O contractor will conduct a management self-assessment of the facility and of the facility's operational readiness. This will include a review of procedures, training, and other items necessary to safely operate the system.

6.5 Agency Inspections and Acceptance

Upon completion of construction activities, the new ISB facility shall be subject to agency inspections, as described in the following sections. After inspections are completed, a report will be prepared to document any issues identified during the inspection and the proposed corrective action. Upon agency acceptance of the facility, ISB initial operations shall proceed as specified in Table 2-1.

6.6.1 Prefinal Inspection

The prefinal inspection will be conducted by the Agencies' project managers (or their designees) at the completion of construction activities. A prefinal inspection checklist shall be prepared and agreed to by the Agencies prior to performing the inspection. Open items will be recorded during the prefinal inspection and an action will be identified to resolve the open items. At the end of the final inspections, the Agencies will determine which open items require closure prior to proceeding with treatment systems operation. Upon acceptance of the prefinal inspection report, initial operations may begin.

6.6.2 Prefinal inspection report

A prefinal inspection report will be prepared to document the results of the prefinal inspection. The report will identify the open items from the inspection, the agreed upon action for closing the open items, and the scheduled closure date for each open item. The prefinal inspection report will be prepared as a secondary document for review by the Agencies. The prefinal inspection report will include the following:

- Completed prefinal inspection checklist
- Identification of open items
- Actions and schedules for closure of open items
- Planned date for final inspection, if required.

6.6.3 Final Inspection

If required, a final inspection shall be performed at the completion of initial operations, as defined in Section 2-2. This inspection will focus on the performance of the ISB system in meeting the objectives of the initial operational period. Upon acceptance of the final inspection report, optimization operations will begin.

6.6.4 Final Inspection Report

A final inspection report shall be prepared to document the results of the initial operations period. This report shall address the following:

- Results of the final inspection
- Evaluation of the effectiveness in meeting treatment system performance and compliance objectives
- Resolution of any outstanding items from the prefinal inspection
- Explanation of any changes from the remedial design and RAWP
- Concurrence that the remedy should proceed into optimization operations
- An O&M Plan (DOE-ID 2002b) update, if necessary.

6.6.5 Remedial Action Report

At the completion of the ISB optimization operations phase, a remedial action report will be prepared. The requirements for this report are discussed in Section 7 and further detailed in the ISB O&M Plan (DOE-ID 2002b). The completion of optimization operations should lead to a determination through the remedial action report that ISB at the hot spot is operational, functional, and ready to move into long-term operations.

7. OPERATIONS AND MAINTENANCE

This section of the ISB RAWP identifies the requirements for operating and maintaining the ISB facility and supporting infrastructure. It also provides the requirements, goals, and objectives for the ISB O&M Plan (DOE-ID 2002b). As described in Section 4, the ISB facility consists of a building and process equipment for injection of electron donor to facilitate ARD of the secondary source and VOCs within the hot spot. The facility also consists of supporting infrastructure including a field lab, a monitoring well array, sampling tools and equipment, the CERCLA Waste Storage Unit , and utilities.

This section of the RAWP addresses the following:

- The operational strategy leading to long-term operations
- Resources needed to support implementation of this operational strategy
- Operations, procedures, and protocols
- Performance and compliance monitoring data analysis and interpretation
- Operational decision-making
- Institutional controls
- Remedy performance review and reporting.

An ISB O&M Plan (DOE-ID 2002b) has been prepared to implement the requirements of this section.

7.1 Operational Approach

A phased implementation strategy is planned for the OU 1-07B ISB remedial component. The planned implementation strategy provides a sequenced approach designed to show measurable progress toward attainment of the compliance and performance objectives.

7.1.1 Interim Operations

Interim operations is the period between the approval of this RAWP and the start of initial operations. Interim operations will be a continuation of the predesign operational activities and will cover activities that support a better understanding of alternate electron donors, development of injection monitoring strategies that support initial operations, ISB model refinement, and continued ISB electron donor addition. Section 5 of this RAWP details the basis and requirements for interim operations.

7.1.2 Initial Operations

Initial operations will start with the completion of the construction of the new ISB Injection Facility, as signified by the completion of the Agency prefinal inspection. Initial operations are planned to occur during the first 2 years following completion of interim operations. During this time, various injection strategies will be used to determine the best method to reduce the downgradient, axial flux from the hot spot so that VOC concentrations will be reduced to less than the MCLs in TAN-28 and -30A. Periodic performance monitoring at designated wells will be conducted as groundwater monitoring, as discussed in Section 8. Initial operations will be complete when the VOC concentrations are below the MCLs at TAN-28 and –30A for a period of 1 year.

7.1.3 Optimization Operations

Optimization operations are planned to occur during the 5 years following completion of initial operations. During this time, various injection strategies will be used to reduce the crossgradient and maintain downgradient flux of VOCs so that concentrations are below the MCLs at Wells PMW-1 and PMW-2. Periodic performance monitoring at designated wells will be conducted as discussed in Sections 2 and 8. Optimization operations will be complete when the VOC concentrations remain below the MCLs at Wells PMW-1 and PMW-2 for a period of 1 year.

7.1.4 Long-Term Operations

Long-term operations will begin following completion of optimization operations and will focus on achievement of hot spot source degradation, while maintaining the reduction of flux from the hot spot in the downgradient and crossgradient directions.

7.2 Operational Resources

Operational resources required to implement the remedial action strategy include both personnel resources and physical infrastructure resources. This section describes the basis and requirements for the organization of personnel (including roles and responsibilities), the physical facilities, and the equipment required for operations.

7.2.1 Organization

The personnel requirements for supporting ISB must include a combination of management, technical, and field resources with the knowledge and capabilities to implement ISB. This includes recognized capabilities for the following:

- Conducting work in accordance with the ROD and this RAWP (within CERCLA regulations) and in compliance with the INEEL Site work control requirements
- Managing and conducting groundwater monitoring
- Managing, operating, and maintaining ISB injection and support facilities
- Administrating and conducting field lab work
- Managing, coordinating, and implementing sample management
- Reviewing and interpreting ISB data
- Recommending operational changes.

7.2.2 In Situ Bioremediation Facilities and Equipment

The ISB injection system shall be operated and maintained so that it meets the requirements of TFR-2539, "Technical and Functional Requirements for the In Situ Bioremediation Design at TAN, OU 1-07B," this RAWP, and the ROD (DOE-ID 1999). Monitoring wells shall be provided that meet the needs of the ISB performance and compliance monitoring strategy (see Section 2). These wells shall be maintained so that ISB performance and compliance monitoring can be performed in accordance with the requirements of the ISB GWMP (INEEL 2002d). Additional monitoring or injection wells may be installed to meet the needs of the project. A field analysis lab that has the capability to analyze for the constituents required by the ISB GWMP shall be operated and maintained.

7.3 Operations Procedures and Protocols

Operational procedures and protocols shall be developed as part of the O&M Plan that govern and guide the implementation of ISB remedial action activities. These procedures and protocols shall be prepared so that requirements defined by Site work control, the ISB RAWP, the ISB GWMP, the O&M Plan, and ARARs are met. The following facilities, operations, and activities shall have procedures and protocols developed:

- In situ bioremediation facility operations
- Groundwater monitoring
- Hydrolab operations
- Field lab operations
- Well maintenance
- Sample management
- Data management.

7.4 Data Analysis and Interpretation

Data analysis and interpretation is critical to the success of the ISB remedial component. Clear performance and compliance goals have been developed and a phased implementation approach is planned. Data analysis and interpretation and reporting will provide the means for the project and the Agencies to make decisions regarding ISB performance and compliance and to determine whether operational changes are required to operate ISB more effectively and efficiently. The ISB O&M Plan (DOE-ID 2002b) provides the plan for data analysis and interpretation that will clearly determine progress of ISB toward the performance, compliance, and completion measures identified in Section 2. Figure 7-1 provides the flow and interface between groundwater monitoring activities (the GWMP) and operations and maintenance (the O&M Plan).

7.5 Operational Decision Making

The phased implementation approach allows the flexibility to modify the operating and monitoring strategy to implement ISB more effectively and efficiently. Inherent in the review and interpretation of performance and compliance data is the opportunity to change injection strategies through the modification of flow rate, quantity, concentration, or injection location. Each phase of the implementation strategy should progressively become more effective and efficient as a result of these changes. The ISB O&M Plan shall include a section that will identify the basis for making routine and non-routine operational decisions.

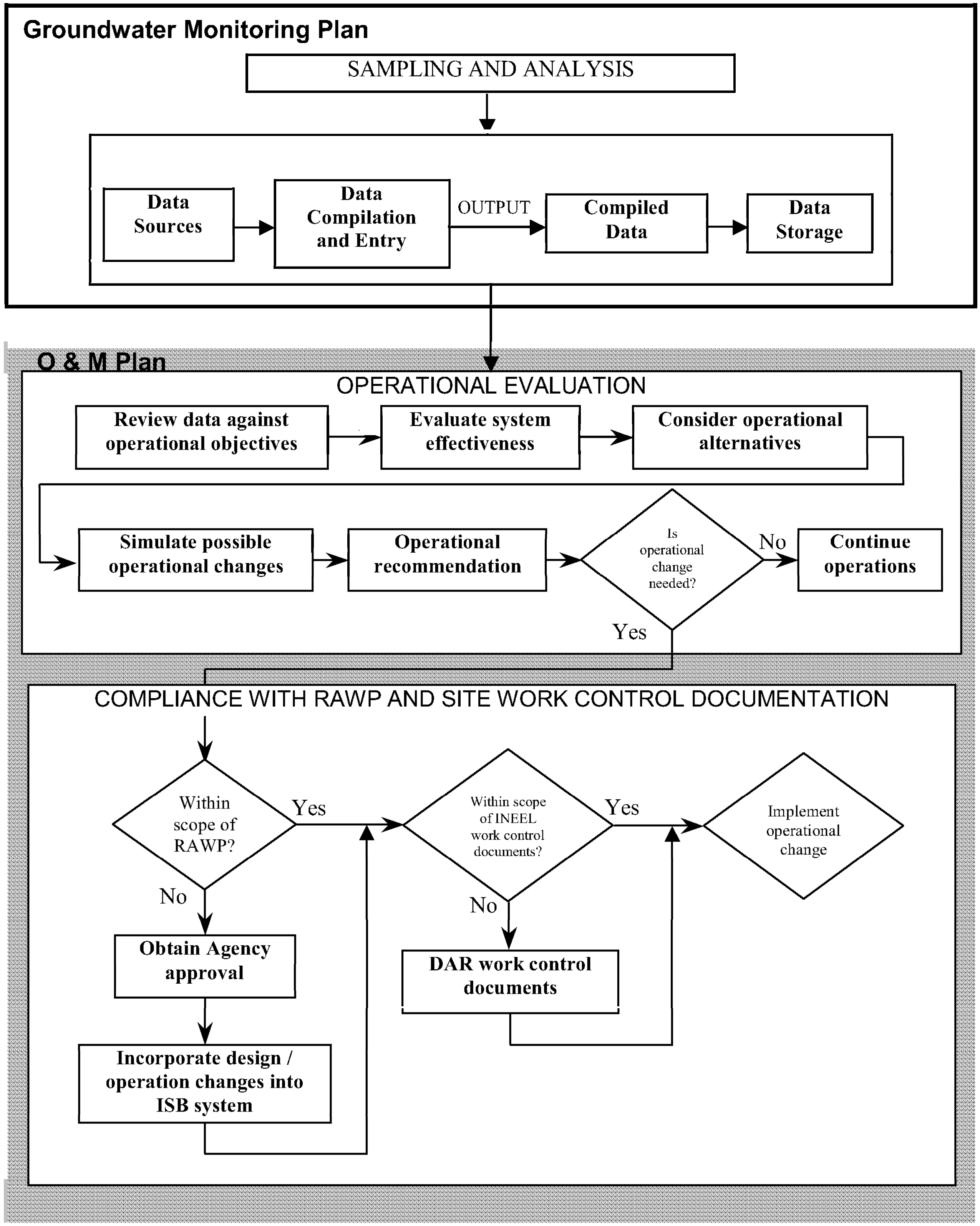


Figure 7-1. Flow and interface between the Groundwater Monitoring Plan and the Operation and Maintenance Plan.

7.6 Institutional Controls

Institutional controls shall be implemented to prevent the use of contaminated groundwater until the RAOs specified in Section 2 have been attained throughout all areas of the contaminated aquifer. Institutional controls shall consist of engineering and administrative controls to protect current and future users from health risks associated with groundwater contamination. The institutional controls will prevent ingestion of contaminated groundwater. Institutional controls for OU 1-07B have been addressed in the OU 1-10 ROD (DOE-ID 1999). These controls include visible restrictions, control of activities, control of well drilling, and control of land use. The ISB O&M Plan shall address ISB-specific institutional controls.

7.7 Remedy Performance Review and Reporting

Reporting requirements for ISB are derived from the need to review the performance and compliance of ISB on a periodic basis, and to judge the combined effect of ISB and the other remedial action components toward achieving total plume restoration. There are three reporting requirements identified for ISB. These requirements include a remedial action report, periodic performance and compliance reports, and remedy performance summary reports.

7.7.1 Prefinal Inspection Report

As specified in the OU 1-07B RD/RA SOW, a prefinal inspection will be conducted at the completion of ISB construction activities. A Prefinal Inspection Report will be generated as a result of this inspection. The enforceable date for this inspection is March 2004. The Prefinal Inspection Report will include the following:

- Inspection checklist
- Discussion of findings
- Outstanding remedial action requirements
- Corrective Action Plans
- RAWP and O&M Plan update
- Final inspection date.

7.7.2 Remedial Action Report

As specified in the OU 1-07B RD/RA SOW (DOE-ID 2001b), a remedial action report will be prepared for the ISB system. This report will be prepared at the completion of the optimization operations after the system has been deemed operational and functional. The remedial action report will be a primary document and a milestone completion date will be established in the prefinal inspection or final inspection report.

The remedial action report discusses as-built conditions and the reasons for any changes, and discusses and memorializes operational testing, shakedown operations, and final inspections. Evaluating effectiveness of the remedy and other topics will result in a determination of whether the remedial action can be determined to be operational and functional. This remedial action report will identify a schedule for the modification of the ISB O&M Plan to define any operational changes resulting from optimization operations, and detail the requirements for determining completion of ISB at the hot spot.

7.7.3 Periodic Performance and Compliance Report

This periodic report will summarize the data gathered for a specific remedial component through a specified period, will provide trending information, and will discuss operational changes and modifications. This report will be summarized, along with the other remedial components, in the annual remedy performance summary report.

The objectives of the periodic report are to evaluate progress of the remedial components toward achievement of performance, compliance, and completion requirements.

This will include the following:

- Performance parameter trends
- Compliance parameter trends
- Data interpretation
- Completion evaluations
- Operational summary
- Operational recommendations.

7.7.4 Remedy Performance Summary Reports

The objective of the remedy performance summary report is to show periodic progress of the entire remedial action toward achievement of meeting RAOs. This report is a roll-up of each remedial component's periodic report and will summarize each remedial component's progress towards achieving compliance and performance objectives for a specified period. The remedy performance summary reports will discuss or recommend operational changes and modifications for the period. The report will also show how the remedial components are working together to remediate the entire contaminant plume.